NASA/TP—2003-212287

Low Earth Orbit Spacecraft Charging Design Guidelines

D. C. Ferguson and G. B. Hillard
Glenn Research Center, Cleveland, Ohio

February 2003

The NASA STI Program Office . . . in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA's counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.

- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.

- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.

- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or cosponsored by NASA.

- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and mission, often concerned with subjects having substantial public interest.

- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results . . . even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at ***http://www.sti.nasa.gov***

- E-mail your question via the Internet to help@sti.nasa.gov

- Fax your question to the NASA Access Help Desk at (301) 621-0134

- Telephone the NASA Access Help Desk at (301) 621-0390

- Write to:
  NASA Access Help Desk
  NASA Center for AeroSpace Information
  800 Elkridge Landing Road
  Linthicum Heights, MD 21090-293

NASA/TP—2003-21228

Low Earth Orbit Spacecraft Charging Design Guidelines

D. C. Ferguson and G. B. Hillard
Glenn Research Center, Cleveland, Ohio

National Aeronautics and
Space Administration

Marshall Space Flight Center • MSFC, Alabama 35812

February 2003

Acknowledgments

Available from:

NASA Center for AeroSpace Information
800 Elkridge Landing Road
Linthicum Heights, MD 21090-2934

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

Low Earth Orbit Spacecraft Charging
Design Guidelines

Prepared By

Dr. G. Barry Hillard
NASA-GRC, Cleveland, OH

Dr. Dale C. Ferguson
NASA-GRC, Cleveland, OH

Submitted By

Dr. Dale C. Ferguson
NASA-GRC, Cleveland, OH

Received/Approved By

Mr. Billy Kaufman
NASA-MSFC, Huntsville, AL

TABLE OF CONTENTS

References and Nomenclature

Many of the references contained herein are from the NASA CASI Technical Report Server and are repeated in the bibliography. References to this database are in the following format: Johnson et al (**19830012345**). References not in the database are of the form Johnson et al (1983), and are listed at the end of the text section.

ACRONYMS

APSA	Advanced Photovoltaic Solar Array
CHAWS	Charging Hazards and Wake Studies
CRRES	Combined Radiation Release Effects Satellite
EAPU	Electric Auxiliary Power Unit
EMI	Electromagnetic Interference
EMU	Extra-vehicular Maneuvering Unit (spacesuit)
EOIM	Effects of Oxygen Interaction with Materials
EOS-AM1	Earth Observing System – Morning Side number 1 (renamed Terra after launch)
EPSAT	Environmental Power System Analysis Tool
Eureca	European Retrievable Carrier
EVA	Extra-Vehicular Activity (spacewalk)
EWB	Environmental WorkBench
FEF	Field Enhancement Factor
FPP	Floating Potential Probe
GEO	Geosynchronous Earth Orbit
IRI	International Reference Ionosphere
ISS	International Space Station
ITAR	International Traffic-in-Arms Regulations
LDEF	Long Duration Exposure Facility
LEO	Low Earth Orbit
MET	Marshall Engineering Thermosphere
MIRIAD	Module Integrator and Rule-based Intelligent Analysis Database
MSIS	Mass Spectrometer Incoherent Scatter
NASCAP	NASA Charging Analyzer Program
NASCAP-2K	NASA/Air Force Spacecraft Charging Analyzer Program
NOAA	National Oceanographic and Atmospheric Administration
PAS-6	Space Systems/Loral Commercial Communications Satellite
PASP Plus	Photovoltaic Array Space Power Plus Diagnostics
PCU	Plasma Contactor Unit
PIX	Plasma Interactions Experiment
PIX-II	Plasma Interactions Experiment - II
PMAD	Power Management and Distribution
PMG	Plasma Motor Generator
ProSEDS	Propulsive Small Expendable Deployer System
RCS	Reaction Control System (attitude thrusters)
RTV	Room Temperature Vulcanized-rubber
SAMPIE	Solar Array Module Plasma Interactions Experiment
SPEAR	Space Power Experiments Aboard Rockets
Tempo-2	Space Systems/Loral Commercial Communications Satellite
TSS-1R	Tethered Satellite System – first reflight

1.0 PREFACE

This document is intended as a design guideline for high-voltage space power systems (>55 volts) that must operate in the plasma environment associated with Low Earth Orbit (LEO). Such power systems, particularly solar arrays, may interact with this environment in a number of ways that are potentially destructive to themselves as well as to the platform or vehicle that has deployed them.

The first objective is to present an overview of current understanding of the various plasma interactions that may result when a high voltage system is operated in the earth's ionosphere. A second objective is to reference common design practices that have exacerbated plasma interactions in the past and to recommend standard practices to eliminate or mitigate such reactions.

This document is intended as a guideline for design applications and is not a requirements specification instrument.

2.0 INTRODUCTION

2.1 Reasons for using High Voltage Systems

High voltage systems are used in space in order to save launch weight. First of all, for the same power level, higher voltages enable use of thinner wires (lighter cabling). This is because $P = IV$, and $V = IR$, so $P = I^2R$ (where P is power, I is current, and V is voltage). If I is decreased by use of higher V, then the wire resistance can be increased, that is, thinner wires may be used, with no increase in power loss due to cabling. In the case of ISS, the decision to use a 160 V primary power system was based on the decreased cable mass possible. Of course, if one uses the same cable mass, higher voltages will enable higher efficiencies, as less power will be lost to resistance in the cables. For very large power systems, the decrease in cable mass can be substantial.

Secondly, some spacecraft functions require high voltages. For example, electric propulsion uses voltages from about 300 V (Hall thrusters) to about 1000 V (ion thrusters). For low voltage power systems, conversion of substantial power to high voltages is required for these spacecraft functions to operate. The weight of the power conversion systems (PMAD) can be a substantial fraction of the total power system weight in these cases. It is more efficient, and can save weight, if the high voltage functions can be directly powered from a high voltage solar array, for instance. If the high voltage function is electric propulsion, we call such a system a direct-drive electric propulsion system. Systems have been proposed that switch between parallel and series combinations of different strings of solar cells in order to facilitate occasional high voltage requirements, but to enable housekeeping functions at a lower voltage.

2.2 Altitude and Latitude Range of Applicability

These guidelines are intended for space systems that spend the majority of their time at altitudes between 200 and 1000 km (usually known as Low Earth Orbit (LEO) applications) and at latitudes between about + and – 50 degrees. That is, space systems that do not (often) encounter the auroral ovals of electron streams, that do not encounter GEO (geosynchronous orbit) charging conditions, and that do not fly through the Van Allen belts. For the extreme radiation protection that is necessary for those orbits, exterior spacecraft charging will likely be a secondary concern.

2.3 Overview of Plasma Interactions

When energized conductors are exposed to plasma, positive surfaces collect electrons while negative surfaces collect ions. The Poisson equation governs charge movement. The Poisson Equation is

$$\nabla^2 \varphi = -4\pi\rho, \tag{2.3}$$

where φ is the potential, and ρ is the charge density. When the charge density is very low, as in GEO, Poisson's equation reduces to Laplace's equation.

Electrons, which are much lighter and more mobile than ions, are collected more easily. Surfaces, therefore, charge to whatever potential they must in order for the net current flow to be zero in equilibrium. A current loop forms that uses the ionosphere as part of the conducting path. The potential that any given surface will achieve is very difficult to model and generally requires full-up testing in a plasma environment. The resulting interactions may be summarized as follows:

- Surfaces that are more negative than ≈ 100 V or so with respect to their surroundings are subject to arcing. These arcs may be either plasma arcs or arcs to adjacent conductors. They are usually a momentary discharge of accumulated energy, lasting only milliseconds, but under some conditions may be sustained. The necessary conditions are for the current and voltage to be maintained above threshold values. Plasma arc thresholds are poorly known but may be as low as 50 V under some conditions.

- Surfaces that are more negative than ≈ 100 V or so are subject to ion bombardment and sputtering. Since the dominant ion is atomic oxygen, care must be taken that chemical attack does not occur as well.

- Surfaces that are positive can easily collect sufficient electrons to present a measurable power drain to the system. Referred to as "parasitic current collection," this can result in a few percent power loss to the system.

- If the power system is negatively grounded, as is most commonly done, the entire vehicle can float negative with respect to the ionosphere. The system potential may get as negative with respect to the ionosphere as the entire power system voltage. For systems with very large areas of high voltage surfaces, such as the International Space Station (ISS), this effect is large, and requires a plasma contactor to mitigate. Experience with high voltage experiments in the Orbiter payload bay indicates that significant charging of the orbiter does not occur. Generally, the large area of exposed metal presented by the main engine bells collects sufficient ion current to balance at a low potential unless ion currents of more than about 30 mA are emitted, or unless the engine bells are in the orbiter wake. If a system is completely isolated from the orbiter body, plasma interactions will result in the system itself floating negative with respect to the orbiter. The magnitude of these effects is difficult to quantify in advance, but should be addressed in the design.

3.0 ENVIRONMENTS

3.1 The Ambient Environment

3.1.1 The Neutral Atmosphere

The dominant environment between 100 and 1000 km is the neutral atmosphere. In this essentially collisionless regime, the gases are in hydrostatic equilibrium. Below about 100 km, where the atmosphere is homogeneous, the composition is approximately 80% N_2 and 18% O_2 with traces of NO_2, Ar, and other gases. Above 100 km atomic oxygen, the result of photodissociation of molecular oxygen, comes to dominate. Above about 800 km the atmosphere is largely atomic hydrogen. At a 500 km altitude, the neutral density varies from $2x10^6$ to $3x10^8$ cm^{-3}, depending on solar activity and position in the orbit. The kinetic temperature of the gas is usually between 500 and 2000 ºK, and the ambient pressure is in the range of 10^{-10} to $5x10^{-8}$ Torr.

The neutral gas environment has been well explored and quantified. Empirical models based on in-situ neutral composition and satellite drag measurements have evolved over the years into reliable predictors of the average composition and thermal structure of the thermosphere. The most notable of these models are: the Mass Spectrometer Incoherent Scatter MSIS-86 (Hedin, **19870053927 A,** and Prag, **19830023945 N**) model based on in-situ satellite observations of neutral concentrations, the MSFC version of the Jacchia model derived from satellite drag measurements (MET, the Marshall Engineering Thermosphere, see **19700031574 N** and Hicky, **19880017376 N**), as well as the U.S. Standard Atmosphere (NOAA, **19770009539 N, 19780023689 N**). These models provide good estimates of the thermosphere environment as functions of altitude, longitude, latitude, local time, magnetic activity and solar activity and are continually updated, as new information becomes available.

3.1.2 The Plasma Environment

On the sunlit hemisphere of the earth, ultraviolet (UV) and extreme-ultraviolet (EUV) radiation penetrates the atmosphere ionizing and exciting the molecules present. As this radiation penetrates, it is increasingly absorbed until, at 60 km altitude it almost completely disappears from the solar spectrum. At the same time, however, the neutral density has been increasing, and as it does the ionization density increases. The result is a fine balance between increasing density and increasing absorption that leads to the formation of layers that is the mean structure that we call the ionosphere. A highly dynamic plasma, the ionosphere's properties vary with altitude, latitude, time of day, and sunspot cycle. Local geomagnetic disturbances can cause dramatic variations over hours to weeks that are difficult to predict. Despite these complications, the broad features of the ionosphere can be described with simple models.

The variability with latitude, known since the 1920's, is so dramatic that the ionosphere is conventionally divided into three distinct regions: high-latitude, mid-latitude, and low-latitude. The high-latitude region, sometimes called the polar region, couples directly to the magnetospheric tail through the auroral magnetic field lines. With low plasma densities and high energies, this coupling subjects it to spectacular variations during geomagnetic substorms. The low-latitude region near the magnetic equator is subject to instabilities linked to changes in the magnetospheric ring current. The easiest region to understand is the mid-latitude region, which most closely follows classical ionospheric models.

Variation with altitude is perhaps the most important parameter for the spacecraft designer. This pronounced vertical structure is not simply a matter of height variation but reflects basic physical processes that differ in the resulting regions. Three processes, in particular, are responsible: (1) the sun's energy is deposited at various heights because of the absorption characteristics of the atmosphere, (2) the physics of recombination depends on density and therefore on altitude, and (3) composition of the atmosphere changes with height.

The lower limit of the ionosphere is somewhat arbitrary since plasma production falls off continuously with decreasing height. Historically, the ionosphere has been assumed to begin at about 50 km from the surface, as this is the altitude where plasma density becomes sufficient to noticeably affect radio wave propagation. There is no distinct upper limit but 2000 km is generally used for most practical applications.

Four layers describe the vertical structure of the ionosphere. In the order of increasing altitude and increasing plasma density, these are designated as D, E, F1, and F2 regions. Their properties are summarized in Table 3.1.2.

Table 3.1.2. Nominal Properties of Ionospheric Layers

Region	Nominal Height of Peak (km)	Plasma density at Noon (cm^{-3})	Plasma density at midnight (cm^{-3})	Dominant Ion
D	90	~1.5 x 10^4	vanishes	O_2^-
E	110	~1.5 x. 10^5	~1 x 10^4	O_2^+
F1	200	~2.5 x 10^5	vanishes	O^+
F2	300	~1.0 x 10^6	~1.0 x 10^5	O^+

Beyond the peak in the F2 layer, electron density decreases monotonically out to several earth-radii. For altitudes up to and including the F2 peak, thermal energies of the electrons and ions are in the range of 0.1 to 0.2 eV, corresponding to kinetic temperatures of 1200 to 2400 °K. Temperature rises monotonically beyond this point reaching several thousand eV in geosynchronous orbits.

The F2 layer is the most important for spacecraft operations. This is where ISS will live, where the Shuttle orbiter and most LEO spacecraft fly, and where the Hubble orbits to photograph the universe. Its boundaries and electron density are highly variable with a general erratic behavior imposed on large daily, seasonal, and solar cycle variations.

Ionospheric plasma distributions within the F-region have been extensively explored since the advent of bottomside sounders, long before in-situ satellite observations were made. As a result, the general morphology of the F-region and some of its more prominent individual features are well understood. While there are detailed features such as localized troughs, localized heating, and short temporal variations that are difficult to model, the overall global structure of the ionosphere is now well understood and excellent ionospheric models exist for estimating and quantifying plasma distributions. In particular, the global International Reference Ionosphere (IRI-90, for example) model provides estimates of plasma concentrations, composition and temperatures, under varying solar activity conditions.

3.2 The Spacecraft-Induced Environment

Spacecraft induced environments can take many forms: neutral gases, ionized gases (plasmas), condensable gases, particulates, radiation, etc. In many cases, these environments can overwhelm the natural environment and may lead to undesirable interactions. Below, we will treat these types of environments separately.

Cold gas thrusters and RCS can significantly increase the localized neutral pressure. This may be dangerous when there are exposed high voltage conductors, as Paschen discharges may occur (see section 5.2.3 below). In general, if the local neutral pressure is more than a milliTorr and less than about a few Torr, high voltage electrical breakdowns may occur. At a voltage of 3500 V, the TSS-1R tether leaked gas into its deployer control reel enclosures and the elevated neutral pressure led to Paschen discharge and loss of the mission. On the SAMPIE Shuttle payload bay experiment, a local gas vent had to be moved to prevent Paschen discharge. Helium is the most dangerous neutral effluent gas, as it has the lowest Paschen breakdown minimum voltage.

Ionized gases can be emitted by plasma sources such as hollow cathode plasma contactors or from neutral gas sources at high positive potentials. Locally, the plasma density can be greater than the ambient plasma density and similar plasma interactions can occur with high voltage components. On ISS, the Plasma Contacting Units (PCUs), when operating, produce a local xenon plasma of much greater density than ambient. It has been estimated that the invisible plasma ball produced is some eight meters in radius before its density decreases below the ambient plasma density in LEO. Arcing and current collection from such a plasma could occur in much the same way as with an ambient plasma, implying that solar arrays and other active sites should be kept out of induced plasma plumes.

Condensable gases are effluents that can condense out on cold components and contaminate their surfaces. Oil and water vapor are two major condensables that can influence the interactions of spacecraft surfaces. In vacuum chamber testing, oil has been shown to prevent snapover on surfaces when high positive voltages are used (see section 4.1.4.3 below). Many oils, however, cannot withstand the LEO atomic oxygen environment on ram-facing surfaces but can build up on wake surfaces. Water vapor released on the night side can condense on insulating surfaces of solar arrays, etc., and may participate in arcing when the arrays become active in sunlight. It has been shown in laboratory testing that solar arrays that have been thoroughly baked out (heated in a vacuum for seven days) lose the water vapor contamination that is important in low voltage (100-300 V) arcing (Vayner et al, **20020038747**). In LEO, however, a cold cycle is about 1/3 of every orbit. Even very well baked-out systems may have recondensation from effluents evolved during the night side of the orbit. Thin layers of condensed contaminants can concentrate electric fields above high voltage conductors, even to the point where they undergo dielectric breakdown.

Particulates can be emitted or shaken from surfaces, but can also result from arcing or sputtering from spacecraft surfaces. Particulates can transfer small amounts of charge from one surface to another, but their major effect is in changing the characteristics of the surfaces to which they adhere. For instance, an insulating particle on a conductor that is at a high potential can concentrate the electric field structure locally, possibly leading to a reduced arcing voltage threshold.

Radiation can embed electrons deep within dielectrics where they can build up for days, weeks, or months until the dielectric breaks down under the induced electric field. In the natural environment, this will mainly happen in the auroral zones, radiation belts, and above the South Atlantic Anomaly, but radiation produced on or within a spacecraft can be important regardless of orbital position. Satellites using radioactive power sources must be designed to ameliorate this “deep-dielectric” charging, which is different from the typical “surface” spacecraft charging.

4.0 PLASMA INTERACTIONS

Exposed high voltage conductors that do not exhibit corona or breakdown in a neutral gas may readily do so if the environment contains a significant ionized component. While a high voltage surface, solar cell interconnects for example, may be exposed to the ionized space plasma by design, surfaces may also find themselves at high voltages because of current collection from the plasma. The resulting equilibrium potentials that are assumed by surfaces result in the following effects that are described in the sections that follow.

- Floating potential shifts – In equilibrium, some parts of the spacecraft may be charged to voltages near the maximum voltage appearing on the solar array.

- Parasitic power drain – Direct loss of power due to current collection. This can be several percent of total power.

- Sputtering – Surfaces that charge negative will attract ions that in turn will result in sputtering of the material.

- Arcing – Negative surfaces undergo arcing when some critical threshold is exceeded.

4.1 Current Collection

4.1.1 The Current-Balance Condition

In the weakly ionized low-density plasma found in LEO, current collection is completely described by Poisson's equation (eqn 2.3). Positive surfaces readily attract electrons while negative surfaces attract the much more massive positive ions only with great difficulty. Since in equilibrium net current collection must be zero, surfaces will charge to equalize the net current of each polarity.

To illustrate the basic effects, consider first a hypothetical experiment. Suppose two metal spheres a few feet in diameter are initially connected by a conductor and placed in LEO some distance apart. Since electrons are collected more easily than ions, both spheres will charge to the same potential, within a volt or two of plasma potential. Now suppose a high voltage battery is placed between them with one sphere connected to the negative terminal and the other to the positive. On earth, in air, such an arrangement would result in half of the battery voltage appearing on each sphere. But in LEO, highly mobile electrons stream to the positive sphere while the negative sphere struggles to collect the massive ions. Both experience and modeling indicate that approximately 90% of the battery voltage will appear on the negative sphere while only 10% will be on the positive one with respect to the plasma potential.

The implications of this are considerable and often expensive. In the case of ISS, for example, the power system consists of solar arrays wired in a series-parallel arrangement to give a 160-volt system. Since the main structure of ISS is "grounded" to the negative end of the array string, the entire space station would "float" more than 140V negative with respect to the ionosphere. Such potentials are beyond the dielectric strength of the anodized coatings on the ISS aluminum structure, and would lead to arcing into the space plasma and eventual destruction of the ISS thermal control system. This prospect required the addition of an active plasma contactor, a xenon hollow cathode discharge unit, to effectively ground the space station to the ionosphere. As it turns out, the ISS solar arrays are unusual in that they are poor electron collectors due to their welded-through design. Atypically, the ISS early mission-build structure usually doesn't charge more than 20 volts or so negative with respect to the surrounding plasma even without the plasma contactors operating. However, as more solar arrays are put up, it is expected that the charging level on ISS will increase dramatically, justifying the added expense of the plasma contactors.

For conducting surfaces that are covered with insulators, some elapsed time may be necessary for the steady state potential situation to be reached. The surfaces will charge until no further charge collection is necessary in equilibrium, and this is tantamount to charging up a capacitor with plate separation equal to the insulator thickness. Ion charging times in LEO may be considerable for typical anodized aluminum thicknesses. It is estimated, for instance, that in the daytime ionosphere, ISS surfaces will take four seconds to fully charge, whereas on the morning terminator where the ionospheric ion density is at its lowest, charging times of forty seconds or more may occur.

4.1.2 Sheath Effects

A positive charged spherical electrode will collect electrons when inserted in a plasma. The volume called the sheath, in which the electrode influences electrons, is larger than the sphere. For low voltages, the sheath thickness will be nearly the same as the Debye length (see eqn. 5.2.3.1). Some electrons will orbit around the electrode and escape out of the sheath. The collected or trapped electrons are said to be orbit-limited and are affected in a complex manner by the radius of the electrode, the electrode voltages, and the temperature and density of the free electrons.

A solar array looks to the plasma like a large rod electrode (like the wires and interconnects that are in contact with the plasma) rather than a spherical probe, and is also surrounded by a sheath. Power loss due to plasma leakage current will become significant above 100 V for positive electrodes and is discussed below. Above a threshold voltage, which differs due to array design, arcing may be observed between the electrodes.

4.1.3 Current Collection by Structures

4.1.3.1 Electron Collection

LEO spacecraft are traveling subsonically with respect to the electrons in the ambient plasma. That is, at the plasma temperatures in LEO, the ambient electrons are moving at speeds greatly in excess of the orbital velocity. Thus, electrons can be collected on any conducting surface (exposed to the undisturbed plasma, i.e. not in the plasma wake) that is not charged more than a few electron temperatures negative. In general, electron collection is well described by probe theory. See for example Chen, 1965. For large surfaces, collection is best described by thin sheath probe theory. For structures smaller than a few times the Debye length (see eqn. 5.2.3.1), orbit-limited theory may be used. Electron current collected from a plasma may be described by the equation $I_e = J_0A_s$, where I_e is the electron current, A_s is the effective surface area for electron collection (either the plasma sheath area or the area of a sphere with the limiting orbit radius), and J_0 is the electron thermal flux, given by

$$J_0 = (n/4)(8kT_e/\pi m_e)^{1/2} = 2.68\text{x}10^{-12}\, nT_e^{1/2}\ \text{Amps/cm}^2, \qquad (4.1.3.1)$$

where n is the electron density per cm^3, and T_e is the electron temperature in eV.

Electron current collection by wires is important in the case of electrodynamic tethers or when structures such as self-extending masts with wire braces are used. For instance, on ISS it was found that several square meters of electron collecting wires on the array masts were connected to ISS ground. The array wing that was positive with respect to the plasma because of $\vec{v} \times \vec{B} \bullet \vec{l}$ effects (described below) acted as an electron collector, and became essentially grounded to the surrounding plasma. This complicated measurements of the vehicle charging due to solar cell electron collection.

An electrodynamic tether is a long wire orbiting in the Earth's magnetic field that uses the electric field generated by its motion, the so-called $\vec{v} \times \vec{B} \bullet \vec{l}$ field (where $\vec{v}$ is the velocity, $\vec{B}$ is the magnetic field, and $\vec{l}$ is the length of the tether or structure), to produce power or propulsion. This concept was proved on orbit by the PMG experiment, where both modes of operation were produced by emitting electrons (by means of plasma contactors) either at the top or bottom of a 500-meter tether to produce power (electron emission at the bottom) or propulsion (electron emission at the top). The maximum $\vec{v} \times \vec{B}$ on a structure in LEO is about 1/3 volt per meter.

In the case of the TSS-1R tether, its 20 km length produced a maximum of about 3500 V potential between its most positive and negative ends, since it wasn't oriented perfectly perpendicular to the velocity vector and the Earth's magnetic field. A satellite at its upper end collected electrons, and an electron gun at the lower end emitted electrons to complete the circuit. When the electron gun was not in operation, a large resistance prevented the Shuttle from being biased thousands of volts negative of its surrounding plasma. However, there remained a large voltage between the tether lower end and the Shuttle orbiter. This enormous bias eventually led to a continuous arc on the tether (see The Continuous Arc, section 4.2.3.1 below), which broke, freeing the satellite and ending the experiment. During the arc, the satellite collected over 1 Amp of electron current to keep the arc going. Probe theory (Cohen et al, **19870010625** N) is usually used to calculate the total current collected by a wire with distributed potentials. However, before the break, TSS-1R demonstrated that a satellite at a high positive potential could collect an anomalously large electron current. See Zhang, et al (**20000110580**), Stone and Raitt (**19990084046** and **20000025437**), and Stone, et al (**19980202347**).

In the new MSFC tether experiment (ProSEDS, the Propulsive Small Expendable Deployer System, Edwards et al, **20000073215**) the electrodynamic tether will be a bare wire, collecting current along its length, rather than just at its ends. In this case, arc mitigation requires, for example, graded insulation at the tether ends to eliminate the so-called triple points where high electric fields may lead to arcing.

Electron collection in LEO is also affected by the vehicle plasma wake. Since orbiting LEO spacecraft are moving supersonically with respect to the ambient ions, there is a wake behind each spacecraft devoid of ions. The electrons that initially enter the wake build up a space charge that repels all other electrons, so the wake can be considered essentially devoid of electrons, compared to the ambient plasma. For most bodies, then, the only part that can collect ambient electrons is the ram-facing side. The CHAWS experiment (Cooke et al, **19950008185** N, Bonito et al, **19970026082** N) showed that a large body in LEO has a very deep wake, with a wake electron density of 10^{-4} of the ambient electron density or less, but with a temperature 10 times or so of the ambient, in agreement with earlier measurements by Raitt, et al (**19840045345 A**) and Murphy et al (**19870037398 A**), among others.

If a piece of conductive structure is surrounded by insulating material and is at a high positive potential relative to the ambient plasma, it may be subject to snapover (see section 4.1.4.3 below). This has the effect of greatly increasing its effective electron surface area, so it can collect an order of magnitude or more current than one would naively suspect.

Insulating structure surfaces reach equilibrium potential with the LEO plasma of only a few volts negative, and do not thereafter collect current.

4.1.3.2 Ion Collection

While electrons are collected from all directions in LEO, LEO spacecraft are moving supersonically with respect to the ions, and therefore ions are only collected by ram surfaces. In fact, since many conducting parts of a structure are far greater in dimension than the plasma sheath, the effective flux of ions to their surfaces is essentially equal to the ram flux of ions on their front-facing surfaces. That is, F = n v, where n is the electron (and ion) number density, and v is the spacecraft velocity. If we let A_{ram} be the ram-facing conductor projected area, and if we let I_i be the ion current and q the ion charge,

$$I_i = q\, n\, v\, A_{ram}, \qquad (4.1.3.2)$$

which for LEO circular orbit becomes 1.2×10^{-13} n A_{ram} Amps, and for a density of about $10^{12}/m^{-3}$, this gives a current of about 0.1 A/m^2. This, then is a convenient rule of thumb for LEO ion current, about 0.1 A per square meter.

Notice that for most purposes, the collected ion current depends only on the electron (and ion) density, whereas the electron current depends on the electron temperature, as well. To first order, then, when there is a current balance condition determining the floating potential, only changes in the electron temperature will cause changes in the floating potential.

Insulating ram surfaces will float at a potential such that the ram ion and thermal electron currents are equal, or only a few volts negative at the most.

4.1.4 Current Collection by Solar Arrays

4.1.4.1 Electron Collection

Electrons may be collected on positively charged cells of solar arrays by the cell interconnects, wiring traces or cell edges. Solar array electron collection is intimately related to Parasitic Power Drain, which is treated in one of the succeeding sections of this document. However, here we will talk in more general terms.

For arrays that have fully exposed interconnects, cell edges or power traces, electron collection is similar to that of wires or small spheres of the same total collecting area as the exposed conductors. One significant difference is due to the fact that many solar cells have insulating coverslides. Since solar arrays by definition generate a voltage across each string, some of the solar cells, interconnects or wiring will be at very different voltages than other parts. If a solar array string has 400 silicon solar cells in series, for instance, one end of the string will be about 200 V more positive than the other. The total electron current collected will be the integral of the collection of all the cells at their respective potentials away from the plasma potential. This depends, of course, on what the system ground is, and what the floating potential of the system is. Wherever the system floats with respect to the ambient plasma, only the cells and traces with positive potentials will collect many electrons.

If the array's exposed conductors are partially hidden from the ambient plasma (such as being underneath overhanging coverslides or between closely spaced solar cells) the coverslides may change the electron collection greatly. It has been shown that a coverslide with an overhang at least as big as the cell-plus-adhesive thickness will block electron collection at the cell edge very effectively, cutting it by a few orders of magnitude. Also, cell edges on cells that are separated by less than about 32 mils have greatly reduced electron collection (Chock, 1991a,b). One way of thinking about this reduced electron collection is that it becomes difficult or impossible for thermal electrons to "make the turn" to be collected at the cell edges. For such solar arrays, it is often the case that the lower the ambient electron temperature, the greater the electron collection, as more of the ambient electrons can "make the turn". This is the case for the ISS arrays, where the greatest amount of electron collection, and thus the worst system charging, occurs when the ambient electron temperature is the lowest.

It is possible for the solar arrays to undergo snapover if they are at high enough positive potentials. See section 4.1.4.3 for details. It is believed that snapover depends on the secondary electron emission characteristics of the solar array insulators. Contamination and/or texturing by atomic oxygen may decrease snapover. In ground tests, oil contamination was seen to completely prevent snapover on some samples. If snapover does occur, it is possible for the solar array to have an effective electron collection area as great as its entire geometrical area, rather than the tiny fraction of the array area that is normally occupied by interconnects or cell edges.

The solar array itself can provide a wake to block its own electron collection. For a sun-pointing array in equatorial LEO, the electron collection will be a maximum near sunrise, and will shut off about noon when the array goes into its own wake. Of course, at night when the plasma is not dense and the array is not generating voltage, the electron collection will be minimal. Thus, solar array electron collection in LEO is only important, and can only lead to a great deal of system charging, for about 1/3 of each orbit (the morning side).

4.1.4.2 Ion Collection

Snapover does not occur for ions and the ion collection for solar arrays is almost always a linear function of negative voltage. Again, the total array collection is the integrated value of all negative cells at their respective potentials away from the ambient plasma, but for most solar arrays, this collection is small compared to ion collection from the structure. In the case of ISS, for example, Ferguson and Gardner (2002) could completely ignore solar array ion collection in modeling the ISS floating potential. When the array is in its wake, ion collection is further reduced.

4.1.4.3 Snapover

The phenomenon of snapover was observed in the early 1980's when power system designers first began experiments with high voltage arrays. While broadly understood, many details of the process are controversial and remain an active area of research.

Suppose a flat conducting plate is covered with an insulator and that in this insulation there is a pinhole. If the plate is biased by a power supply and placed in plasma, it will collect current. For low voltages, current collection will be linear with bias voltage. While the remaining surface cannot collect charge, it nevertheless is the source of an increasing electric field. This field results in ion bombardment of the insulator and secondary electron emission. The result is a rapidly growing sheath that collects charge and funnels it effectively to the pinhole. What is observed then is this: As voltage is increased from zero, current is collected linearly. At some point, current collection increases exponentially and finally saturates at a current level that is approximately the same as if the entire plate were conducting. On a solar array, the interconnects, wire traces, or cell edges act like pinholes – they are the conductors to which the current is funneled. The solar cell substrate and/or coverslides act like the insulator in the above example – they are the dielectric that furnishes the secondary electrons and acts as a current-collecting plate.

The phenomenon is quite striking with conventional solar array designs and is easily observed in plasma test chambers. Here we have solar cells that are covered by insulating cover slides connected to each other by small, exposed metallic interconnects. At low voltages the interconnects collect current roughly linearly with voltage. At around 150-200 volts the onset of snapover can be observed and by about 600 volts the array is fully "snapped over."

Avoiding snapover has become a major design issue. Strategies include insulating all surfaces, where practical, and choosing insulators with low secondary electron emission yields. While simply insulating all conducting surfaces provides initial protection, cracks or pinholes are difficult to avoid when materials must withstand years of exposure to harsh space conditions. It should be noted that pinholes in high voltage insulation usually expand as the large current density funneled through them destroys additional material. On the other hand, experience has shown that cracks or pinholes, if much smaller than the Debye length in the plasma, do not snap over. ($\lambda_D = 743(T_e/n)^{1/2}$, in cm, where T_e is the electron temperature in eV, and n is the electron density in cm^{-3}. See eqn.5.2.3.1. For LEO conditions, λ_D may be as small as 0.1 cm.)

As an example of a snapover-like effect on real solar arrays, we consider the data in Figure 1. The Advanced Photovoltaic Solar Array (APSA) was a very lightweight design proposed for widespread use in the early 1990's. Originally designed for deployment in GEO, the blanket material was carbon-loaded Kapton®, which had sufficient conductivity to avoid differential charging that is a common problem in that environment. Proposals to adapt APSA technology to LEO recognized that atomic oxygen would destroy the blanket material within a matter of days. The LEO prototype was therefore designed with a blanket of Germanium-coated Kapton®, which would be resistant to atomic oxygen attack. This material is not as conducting as carbon but is still a weak conductor.

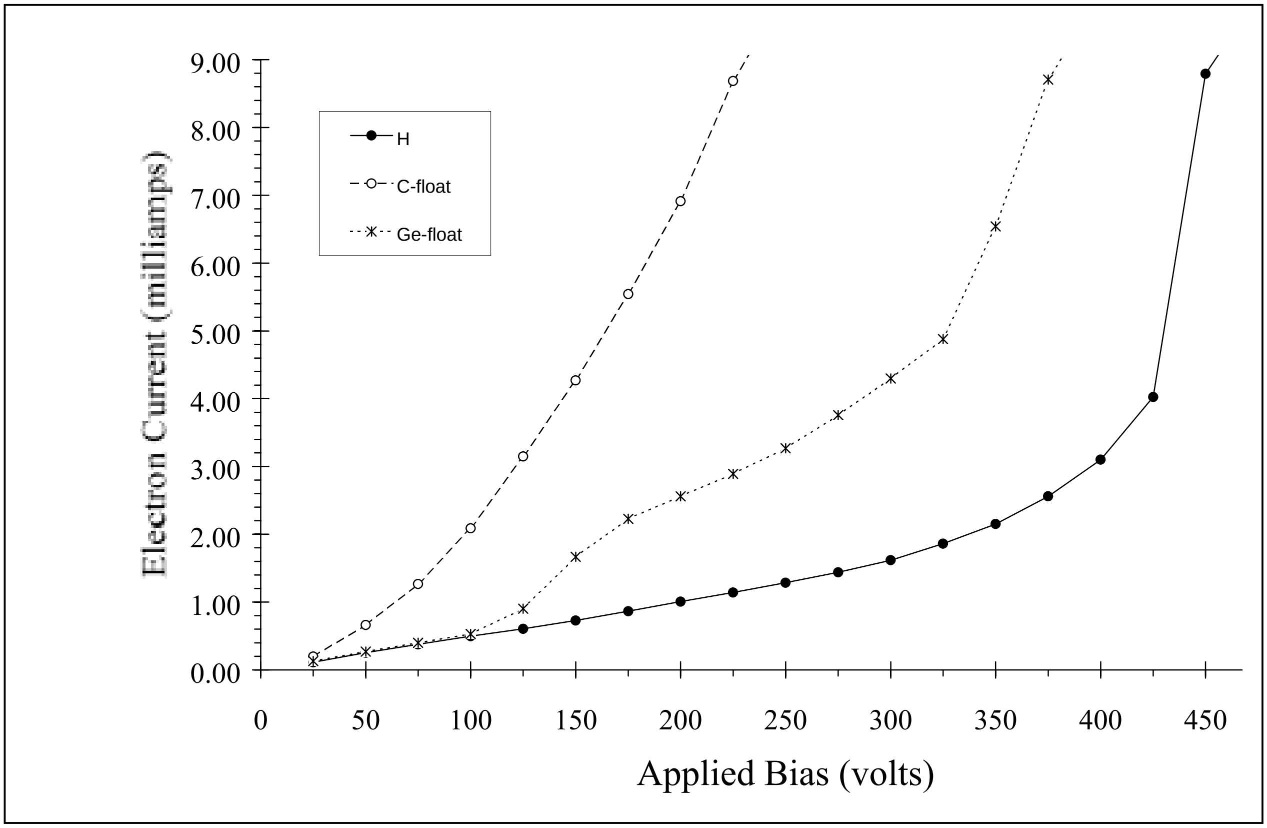

Figure 1 - Electron Current vs. bias for three solar array blanket materials

Three sample coupons were constructed that were as identical as possible except for the blanket material. One was made from uncoated Kapton®, while the other two had blankets coated with Carbon and Germanium respectively. They were tested in a space simulation chamber for current collection as a function of applied bias voltage. As the results show, the highly insulating Kapton®-H, shown by the curve designated "H", collected current linearly until around 300 volts. Current rose rapidly until about 400 volts when it became exponential, the signature of snapover. The weakly conducting Germanium coated blanket collected linearly only until about 125 volts when it began its rapid rise while the much more conducting carbon blanket collected exponentially almost from the beginning. These experiments showed that the blanket itself could become involved in the snapover process and pointed to the critical need to test all proposed array coatings for plasma effects. (See Hillard, **19950038531 A**). That is, with conductive blankets, the inherent conductivity can substitute for the secondary electron-induced conductivity to give "snapover" even at low voltages.

4.1.4.4 Parasitic Power Drain

Current collection from solar arrays or other conducting surfaces not only poses the threat of damage to the surfaces involved, but also can reach levels that result in a significant loss of power. There have been many efforts over the years to use the basic equations of plasma physics to estimate the magnitude of this loss and we will present one of them as illustrative of the effect.

The high-voltage solar-cell array for a high power satellite looks more like a sheet electrode than like a spherical probe. K. L. Kennerud developed a method of analyzing the leakage current from such arrays (**19740009675** N) based on fundamental equations developed by I. Langmuir. Kennerud's technique converts the linear array into a sphere having the same area, and then he calculates the radius of the electron sheath surrounding the array. His experiments with small positively charged solar-cell panels correlated well with his predictions.

His results are shown in Table 4.1.4.4 below and may be used to understand how the effect scales with altitude for the hypothetical solar array that he used.

Table 4.1.4.4. Leakage current from positively charged solar arrays

Array Altitude (km)	Electron Density, N_e (cm^{-3})	Electron Temperature (K)	Leakage Current		Power Loss, percent of Generated
			nA/cm^2	A per 1500V String*	
500	$6x10^5$	3,000	824.5	0.8494	7.72
700	$2x10^5$	3,000	274.8	0.2831	2.57
1,000	$7x10^4$	3,000	96.19	0.0990	0.90
2,000	$2x10^4$	3,200	28.38	0.0292	0.265
30,000	$1x10^2$	13,600	0.29	0.0003	0

* The string is 0.404 m by 255 m, with an area of 103.02 m^2.

Such rough calculations fail when the geometry becomes more complex. In particular, solar arrays with hidden interconnects, such as the ISS arrays, may collect current very differently than one with exposed interconnects. The ISS solar arrays, counter to intuition, collect more current at low electron temperatures than at high electron temperatures. Models have shown that this is due to an electric field barrier to high-energy electrons. However, modeling electron collection by using spheres of equivalent “effective” area is very useful, and is incorporated in computer codes such as EWB, for instance. Modern computer codes, such as the NASCAP series described below, will provide accurate estimates of parasitic power loss for any geometry. At high positive potentials snapover can make a solar array appear to be completely conductive. In addition, if a glow discharge due to neutral gas ionization occurs on the array, the current collected may shoot up to tremendous levels

(Ferguson et al, 1998, Vayner et al, **19990113111**). Finally, electric propulsion thrusters or plasma contactors, if placed in the vicinity of solar arrays, can short-circuit the plasma collection circuit, and constitute a significant drain on the system power supply.

4.1.5 Current Collection at High Frequencies

In general, little work has been done on plasma effects involving high frequency power systems. While significant new effects are not expected, most parameters of interest, such as corona inception and extinction voltages, are expected to exhibit frequency dependence. One effect did emerge in the early 1990's concerning insulated conductors energized with 20 kHz ac that were exposed to LEO plasma conditions. This work was underway because Space Station Freedom was originally designed to use such a power system (Button et al, **19900051071 A**). Research was suspended when the space station was reconfigured to use dc power.

If a conductor energized with low frequency ac is placed in LEO plasma, electrons are attracted to the insulating surface during the positive part of the cycle. These electrons "stick" to the material with a characteristic energy and are not repelled when the polarity changes to negative. Ions, however, are attracted during the negative part of the cycle and neutralize the electron charge for no net effect. At high frequencies this neutralization process does not occur. Highly mobile electrons are still attracted during the positive part of the cycle but ions, because of the much larger mass, cannot respond to the rapidly changing field. The outer surface therefore charges to a negative potential close to the peak voltage on the power system waveform and remains charged.

While ions cannot respond to the rapidly changing voltage waveform, they do respond to the buildup of negative charge on the surface. The resulting ion flux results in equilibrium where the surface is charged, as a rule of thumb, to about 90% of the peak voltage level used in the system. For a high voltage system, ions will easily acquire sufficient energy to sputter material from the insulation. Such charging may have a number of other implications that could include an arcing hazard, depending on where such surfaces are located with respect to other conductors.

4.1.6 Wake Effects

Because a LEO spacecraft is supersonic with respect to the ions it flies through, a wake, essentially devoid of plasma particles of both signs, will form behind it. In LEO, the ambient ions are traveling at a thermal speed of about $9.79 \times 10^5 (T_i/m_i)^{1/2}$ cm/s, where Ti is the ion temperature in eV, and m_i is the ion mass in amu. For a T_i of 0.2 eV (typical) and $m_i = 16$ (atomic oxygen), this gives an ion speed of about 1.1×10^5 cm/s, and a mach ratio of about 5 for LEO orbit. Thus, the wake of a large body will extend as a cone about five times as long as it is wide. In this region (a sort of umbra), ion and electron densities will be severely depressed, and the remaining plasma will be at a high temperature (perhaps ten times that of the ambient plasma). In a surrounding region (a kind of penumbra), bounded by the shock wave, the plasma will be disturbed, but it is believed that the major effect will be hotter electrons than ambient. Beyond the penumbra, the plasma will be normal. See, for example, Ferguson (**19850014185 N**). Measured details of wake structure may be found in Raitt, et al (**19840045345 A**) and Murphy et al (**19870037398 A**),

Instruments to measure plasma parameters in LEO should be placed beyond the plasma sheath surrounding the structure (normally a distance of 0.3 to 0.6 meters will suffice) and outside the wake of any structural element. In the case of the floating potential probe (FPP) on ISS, a compromise position was chosen that placed FPP outside the umbra of any structural element and on a pole to place it outside the plasma sheath, but it could not be placed out of the penumbra of some structural elements. Resulting plasma temperatures measured by FPP are considered to be higher than ambient temperatures, but the plasma densities seem reasonable. For instruments in such suboptimal placements, calibration must be done to convert measured parameters into ambient values, and such work is now proceeding with FPP. For a detailed discussion of wakes of large and small bodies orbiting in LEO, see Samir et al (**19860037062**). In a practical document, we cannot go into great scientific detail about wake structure, but invite the reader to a literature search under the name of Stone, N.H., who had devoted much of his life to researching this topic.

4.2 Arcing

4.2.1 Solar Array Arcing

4.2.1.1 Background

Solar arrays have proven to be the major source of reliable long-term electric power for both manned and unmanned orbital spacecraft. In the early days of spaceflight, a few satellites used energy sources other than solar arrays and batteries, such as fuel cells or thermo-electric prime power sources. By 1970, because of extended mission times as well as increased power requirements, the majority of spacecraft primary power systems used solar arrays and rechargeable batteries to supply the required 28 V. The choice of 28 volts for the main bus voltage was made to take advantage of long-existing standards and practices within the aircraft industry.

Plasma interactions at 28 V have not been generally considered a degradation factor of consequence. The only noted exceptions to their benign nature have occurred under extreme environmental conditions, especially during geomagnetic substorms for spacecraft operating at high inclinations. For low inclination spacecraft, i.e. those that completely avoid the auroral oval, 28-volt systems have not been observed to arc.

As the power requirements for spacecraft increased, however, high voltage solar arrays were baselined to minimize total mass and increase power production efficiency. With the advent of 100 V systems in the late 1980's, arcing began to be observed on a number of spacecraft.

Solar array arcs are generally characterized by several parameters.

- Breakdown voltage - The voltage required to initiate an arc depends on the plasma flux density, the system bias voltage, insulation, and construction and arrangement of the solar cells and solar cell strings. Voltage breakdown for a well-designed solar array can initiate as low as 75 V (negative biased) for spacecraft operating in a LEO plasma environment. Vayner et al (**20010072444**) have shown that arc thresholds of less than about 300 V are invariably due to surface contamination with water and/or other contaminants.

- Temporal profile - The time from initiation to maximum current may be from a fraction of a microsecond to seconds, depending on the power source and the circuit impedance. The total duration of an arc may be from microseconds to indefinitely sustained.

- Current profile - The arc current can be as large as 100 to 1,000 Amperes depending on the capacitance of the solar array (see Figure 2, from Snyder [Purvis et al, 1986]).

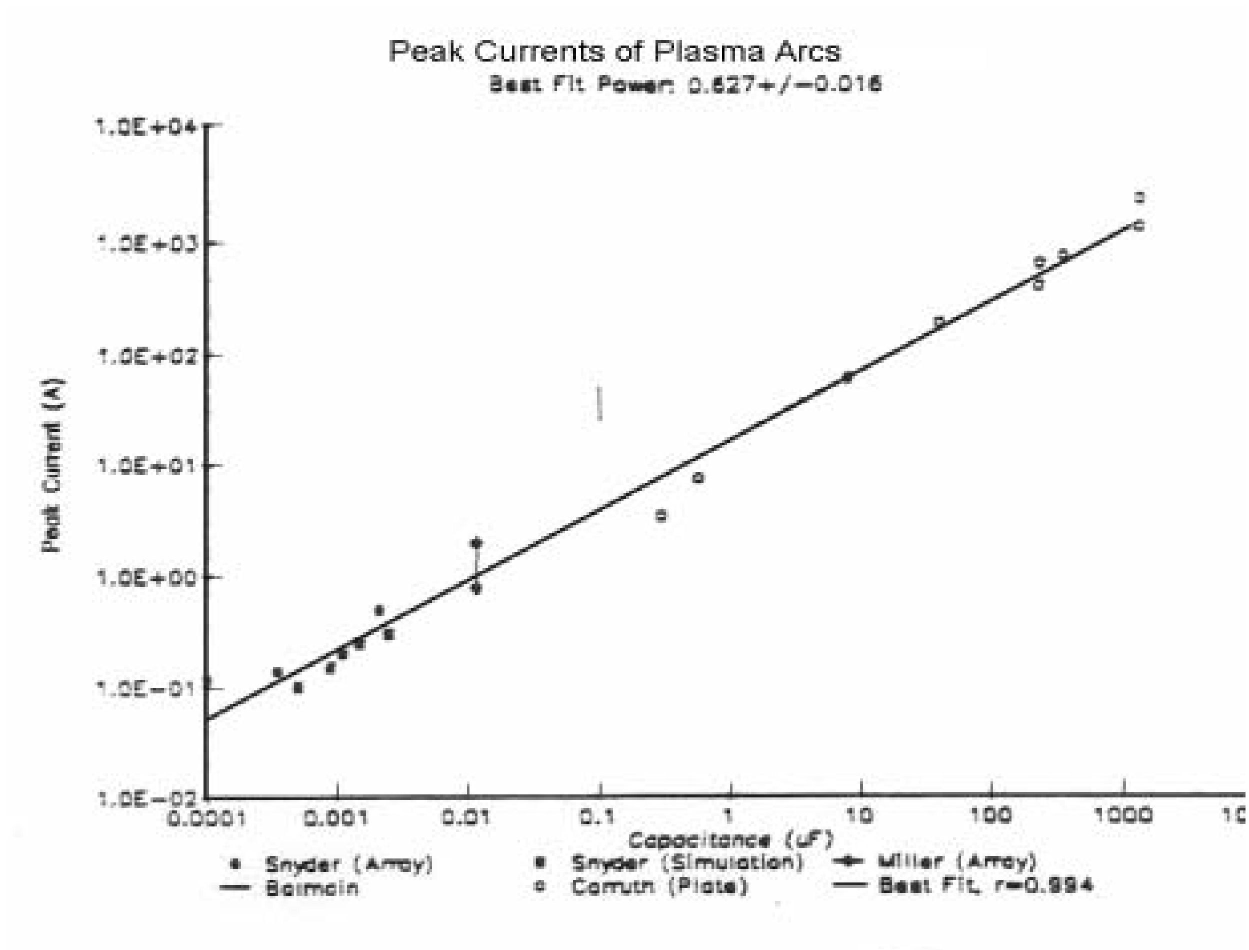

Figure 2 - Peak arc current versus capacitance

While many different taxonomies have been proposed for classifying arcs based on combinations of the above properties, these have generally been the work of physicists and have been designed to clarify issues for further research. For the design engineer concerned with risk mitigation we will use a simpler scheme that assigns arcs to only two categories.

1. Fast transients - These are the most common solar array arc and are characterized by rapid rise time followed by extinction in a time that is several times the rise time. The critical parameter is that the energy involved is stored in whatever capacitance is available. The available capacitance may vary from a single array string to the entire spacecraft depending on design. These arcs give rise to electromagnetic interference (EMI) but otherwise are not generally associated with significant permanent damage on small spacecraft. On ISS and other high-power systems, however, the energy stored in the capacitance electrically connected to the arc site could cause significant damage to a solar cell or power trace. Of course, repeated arcs at the same arc site can lead to degradation and failure even if the individual arcs are not very energetic.

2. Sustained arcs (continuous arcs) - These are the events that have been attributed with the destruction of on-orbit solar arrays. Generally, the process begins with a fast transient (a so-called “trigger arc”). Under some conditions, the transient develops into an arc that is fed directly by the entire array, effectively becoming a short-circuit. Such events invariably involve large quantities of energy and can be severely damaging to cells, interconnects or power traces.

Each of these will be discussed in more detail in sections to follow. Since all events begin as a fast transient and most do not evolve beyond this phase, this type of arc has been the object of most research in solar array arcing. The more destructive continuous arc has only been observed in the past few years as power levels have increased (causing higher and higher string voltages to be used) and as the drive to ever more compact string layouts has resulted in some unfortunate design choices. The sections that follow are therefore organized around the fast transient event. We will turn to the continuous arc in the final section of this topic with a summary of what is known at this time.

4.2.1.2 Initiation Mechanism

As one might expect, the initiation of a solar array arc depends on the presence of a strong local electric field. Frequently, the source is an exposed interconnect which, depending on its location in the string, can be at high potential.

Most problematic are arcs that initiate at triple points. A triple point is a point in space where insulator, conductor, and plasma all meet. For a solar cell operating in LEO, this is usually the solar cell interconnect, but it can also be the edge of the solar cell (near the substrate or the coverslide). It has been shown that arcing on solar arrays at voltages less than about 1000 V is always intermediated by the presence of a plasma. Identical samples to those that arced at 100 V in a plasma have been shown to withstand 1000 V bias in a pure vacuum.

Arcs have been observed at relatively low potentials (as low as 75 V) when conductor surfaces are biased negative near insulator surfaces in the presence of a plasma. Arc rate is strongly dependent on plasma density and on coverslide temperature, which affects the surface conductivity. It may range from intermittent (on a scale of minutes and perhaps hours or longer), to several per second. Arc currents observed in ground tests are on the order of an Ampere and may last several microseconds. These characteristics depend on the capacitance to space, increasing with increasing capacitance. These arcs are usually associated with solar cell array interconnects, but have also been observed on biased conductor surfaces covered with dielectric strips. They are likely to be of concern whenever conducting surfaces at negative potentials with respect to plasma abut insulating surfaces.

Several mechanisms are proposed for initiation of the arcs. Because much higher voltages are required to initiate arcs in a pure vacuum than in a plasma, the plasma arc must not be a so-called vacuum arc, but is initiated at much lower electric field strengths. One favored mechanism proposes that a thin layer of relatively insulating film develops on the conductor. High electric fields develop across the film due to ion collection on the exposed face. The resulting electric field across the film causes electron emission from the conductor through the film into the plasma (Jongeward et al, **19860040787** A). A second, though perhaps related mechanism, assumes that the high electric fields at the edge of the dielectric cause propagation of secondary electrons to the dielectric surface from near the conductor-dielectric-vacuum interface. Also, sufficiently intense electric fields may develop locally at the tips of structure built on the conductor surface due to the mobility of surface atoms driven by the electric field resulting from the presence of the nearby dielectric surface. However, this “structure” related arcing requires thin whiskers that have not been seen on realistic samples. Finally, gas desorbed from dielectric surfaces by electron impact can become ionized and serve as an ideal current path for the full-fledged arc.

At this time, no complete theories exist for the arc mechanism on solar cell arrays in a plasma. All require inclusion of an empirical factor to produce the observed low arcing voltage thresholds at triple points. Experimental evidence indicates that an electron emission mechanism plays an important role in producing the arcs. A preliminary theory has been advanced which relates electron emission to the charging of a "dirty" layer on metal surfaces and the electric fields near an insulator-conductor-insulator surface configuration. This theory accounts for some of the experimental observations.

An electron emission mechanism for solar array arcing is consistent with several experimental observations. Kennerud (**19740009675** N) observed that the apparent ion collection of a solar cell array was enhanced by an order of magnitude prior to arcing. This could be accounted for either by electron emission, or by an increase in ion density of the plasma. Snyder and Tyree (**19850002825** N) observed this emission as an increase in electron current collected by sensors in the tank with the solar array. They also noticed that these currents did not cease when the plasma generator was turned off. Arcing could still occur with no plasma in the tank as long as these emission currents were detected. Snyder

(**19840019755** N) also noticed that arcs did not take place in a very low-density plasma (10^2 cm^{-3}).

The occurrence of arcs can be predicted from the potential of the solar array cover slides relative to the plasma. In a very low-density plasma, even at relatively high bias voltages, the cover slides remained near plasma ground and no arcs occurred. At higher plasma densities, the cover slide potentials became several tens of volts more negative than plasma ground. When this condition existed, arcs occurred. Electrons from the plasma do not have enough energy to pass through the energy barrier set up by the biased interconnects and reach the insulator surfaces (Parks et al., **19860035096** A). Electrons emitted from the interconnects of the array cause the cover slides to charge negatively relative to the plasma. These observations indicate that electron emission is necessary before the current pulse of the arcs can occur. Doreswamy, Grier, Vayner and Galofaro (Galofaro et al, **19990052584)** have shown that an arc is always preceded by a nanosecond burst of electrons from the arc site. This burst may also ignite arcs on nearby surfaces.

Jongeward et al. (**19860040787** A) proposed an arc mechanism model to account for this emission. The negatively biased interconnects tend to collect positive ions from the plasma. A layer of relatively high resistance material several Angstroms thick may collect a sufficiently high surface density of positive ions to permit field emission of electrons from the region. This mechanism was first proposed to account for enhanced secondary electron yields from oxide films (Malter, 1936). Electrons emitted from this site are accelerated by the electric field between the cell or interconnect and the coverglass surface and strike the coverglass edge, which then emits secondary electrons in a cascade. Adsorbed gases are desorbed by electron impact. Ionization of these desorbed gases produces a dense plasma which is necessary for large currents to flow (Cho and Hastings, **19910034758** A). Some inferences can be made that are consistent with the experimental observations. There must be enough ion flux to the interconnect to maintain a high surface charge on the high resistance layer. The metal-insulator geometry provides a focusing effect which increases the ion flux to the interconnect and maintains the surface charge density. Field emission accounts for the relatively steady emission, which probably represents a metastable situation. The solar array arcs arise when this stability breaks down producing increased electron emission.

This model predicts the time duration and current of the arcs to almost a factor of two. Progress is also being made in predicting arc rates using this model. For instance, de la Cruz et al (**19960028210** A) were successful in modeling the arc rates and thresholds seen in the SAMPIE experiment. The importance of adsorbed contaminants has been experimentally verified by Vayner et al (**20020038747**, and subsequent).

Brandhorst and Best (**20010056310**) have shown that solar array arcs may be initiated in the laboratory by simulated micrometeoroid strikes.

4.2.1.3 Arcing Threshold

In an attempt to consolidate all known arcing information on solar arrays, Ferguson (**19860018653** N) has analyzed the arcing data from the PIX II array and compared it to other ground and flight data (see Figure 3). Figure 3 is reproduced in Hastings et al (**19920044359** A) and Hastings (1995, and subsequent) with theoretical predictions superimposed. The ground and flight data reported therein are from Ferguson (**19860018653** N). He concluded that (and we further comment in parenthesis):

A. A threshold for arcing of 2x2 cm solar cells into the plasma appears to exist near -230 V (with respect to the plasma). A threshold may exist for 5.9x5.9 cm cells at a lower voltage, but is not yet proven. (More modern studies have found thresholds as low as 75 V for specific array designs. The difference in threshold is more likely due to coverslide thickness than cell size.)

B. The arc rate at voltages above the threshold seems to be a power law of the voltage. This, combined with a nearly linear dependence of arc rate on plasma density, produces an apparent "threshold" which varies with plasma density. (Here, “above” means for voltages more negative than the threshold voltage. The apparent threshold is just because the “waiting time” for an arc to occur has exceeded the measurement interval.)

C. The arc rate decreases to a steady value on a timescale of a few hours. It is not yet clear whether this is due to repeated arcing or to exposure to the plasma. (Further studies have shown [Vayner et al, **20020038747**, Galofaro et al, **20020038846**] that this is due to both causes – outgassing into the vacuum removes contaminants over time, and arcs destroy contaminant islands in their burst of plasma.)

D. The arc rate may depend on the plasma density to the first power, on the square root of the ion temperature and inversely on the square root of the ion mass. (That is, on the ion flux onto the sample.)

E. No significant dependence of the arc rate on the number of cells or interconnects could be found in the data. (This is still the case – the most likely arc site goes first, but there is no dearth of other arc sites when the charge builds back up. That this occurred in the data showed that each arc nearly completely discharged the available capacitance. Schemes can be proposed to prevent an arc from communicating with other cells or strings than the one on which it occurs, but in general all electrically connected cells or strings will contribute capacitance-stored energy to the discharge.)

F. The arc rate is greater in the flight test conditions than in ground tests, possibly because of the atomic oxygen plasma in LEO. (It is unclear what other differences affect the arc rate, although cell temperature is clearly important in subsequent flight data, such as PASP-Plus.)

G. The arc rate in cells with exposed conductors on the backs, as in welded-through substrates, is higher at all likely arcing voltages than the rate for cells exposed to the plasma only on the fronts. (This may be due to the copper exposed on the backs, as contrasted with silver on the fronts).

Studies by Upschulte et al (**19950038524** A) and Hastings et al (**19930048570** A) confirm that a voltage threshold exists for solar array arcing, and for certain values of a parameter called the Field Enhancement Factor (FEF, see Cho et al **19920071023** A), reasonable values of the threshold are predicted. Vayner et al (**20010072444**, and subsequent) have shown that arcing is enhanced primarily by the presence of desorbing contaminant layers, although thin coverslides and other geometrical factors can also enhance the electric field and lower the arc threshold. Snyder et al (1998) have shown that hot arrays (100^{o} C) have a higher arc threshold than cool arrays (room temp.) in ground tests, presumably because the coverslides become more conductive at high temperatures. These results were confirmed on orbit in the PASP Plus experiment for the APSA-type solar arrays (Soldi et al, **19960024017**).

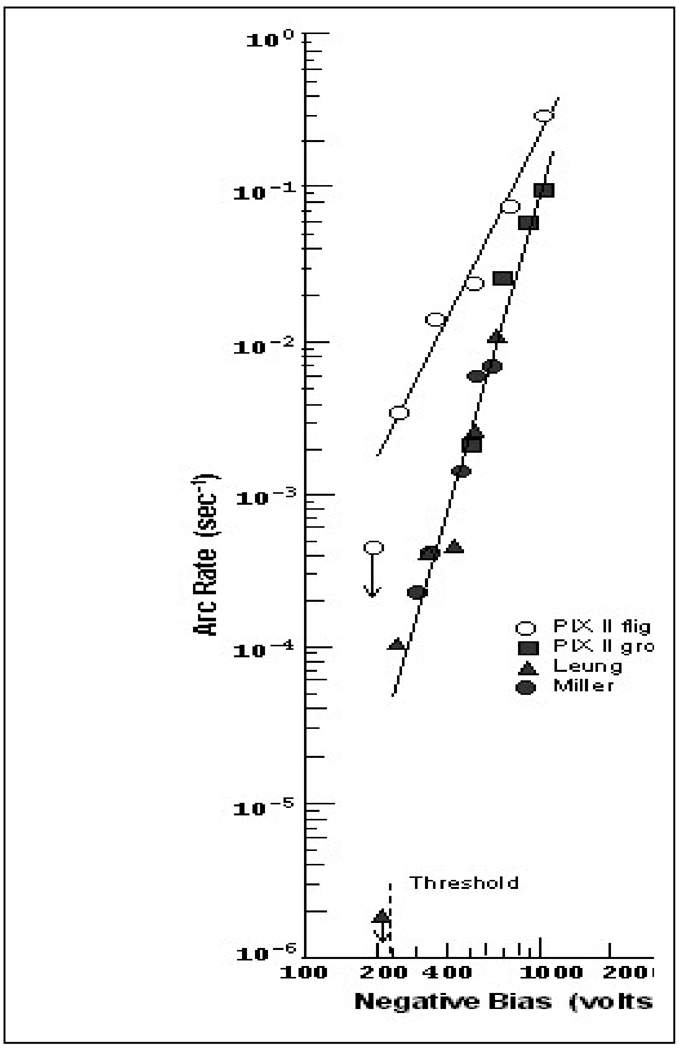

Figure 3 - Arc rate versus voltage for standard interconnect cells. Threshold is inferred from the plasma arcing measurements.

4.2.1.4 Typical Waveform

Figure 4 (Snyder and Tyree, **19850002825** N) shows the time dependence of the current from an array segment during an arc. A typical arcing sequence has four regions:

I. The arc is initiated and the current increases to a peak value. The rise time varies from less than 0.1 μs to about 1 μs. The peak amplitude and rise time depend primarily on the capacitance electrically connected to the arc site.

II. The current then remains near the peak value for some time.

III. The current decreases with a roughly exponential decay. The decay time associated with the termination of the arc should not be confused with the total duration of the arc. During this decay the current is space charge limited.

IV. The arc terminates suddenly and the array begins to recharge to the bias voltage. At this point the coverslides of the array are substantially positive relative to both space and the arc point. The coverslides collect a substantial electron current from the plasma, resulting in the observation of a slight negative pulse.

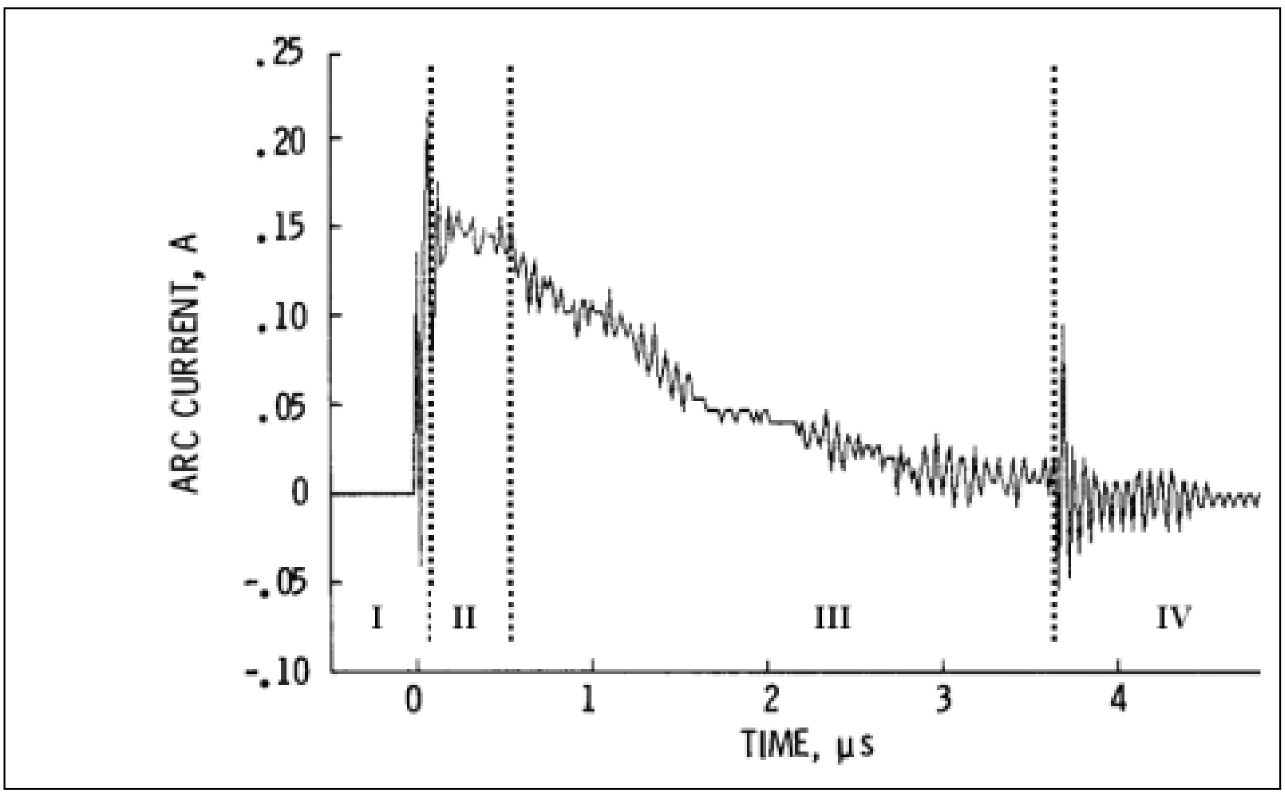

Figure 4 - Typical waveform for an arc

4.2.1.5 System Response

Arc currents may flow out into the surrounding plasma, with the return currents distributed over wide areas of other spacecraft surfaces.

During an arc two things will happen. As charge leaves during an arc the potential of the arc site changes and the potential of the system, electrically connected to the arc site, will change. As a result of the potential change, return currents will flow to restore equilibrium. The return currents will come both from the surrounding plasma and from the arc-generated plasma. There are two impacts on other systems. The structure currents will look like noise to instrumentation. And the change in spacecraft ground will affect plasma currents to surfaces. In principle, these responses are the same for transients of any cause: docking, thruster firings, waste dumps and beam experiments. Only the magnitudes will be different.

The response of a system to an arc can be estimated from a circuit analysis including terms to approximate the capacitances of the surfaces to space. An arc can be simulated in such a model by injecting an appropriate current pulse and computing the circuit transients [Metz, 1986].

4.2.1.6 Damage Potential

Initial indications that sustained arcs could cause substantial damage to solar arrays was obtained in testing where the bias power supply, intended to impress a potential difference between an array and its coverslides, was not sufficiently isolated from the sample when arcs occurred (see Continuous Arcs, section 4.2.3.1 below). Tests at LeRC (now GRC) in the 1980's (Miller, **19850014187 N**) showed that solar array interconnects could be melted by arc currents as large as 40 A.

Although pictures of damage produced by on-orbit sustained arcs are rare, because most arrays that have arced are not recovered, we do have photos of damage suffered by the ESA Eureca spacecraft that was recovered by the Space Shuttle. Figure 5 shows a sustained arc site on its solar arrays. In this case, the sustained arc eventually burned through the array substrate to the grounded backing, completely shorting the array string to ground.

The Space Systems Loral satellites PAS-6 and Tempo-2 underwent sustained arcing in GEO that led to several shorted solar array strings and a severe loss of power. Although these were GEO failures, after the initial arc occurs it is believed that the mechanism for sustained arcing is the same for LEO. Subsequent SS/Loral satellites underwent extensive modification to prevent sustained arcing, and have had no similar string failures since that time.

A sustained arc on a test sample of arrays for the EOS-AM1 satellite (now known as Terra), was seen in laboratory testing. In Figure 6, we see a frame from the videotape taken during the test, and in Figure 7 is the vicinity of the site where the arc occurred. The capacitor used in this test to start the initial arc was 5 microfarads, and the arc started and continued until the power supply was manually shut off seconds later. The solar array string was completely shorted out. This test led to rework of the entire array strings on the Terra satellite to prevent arcing on orbit.

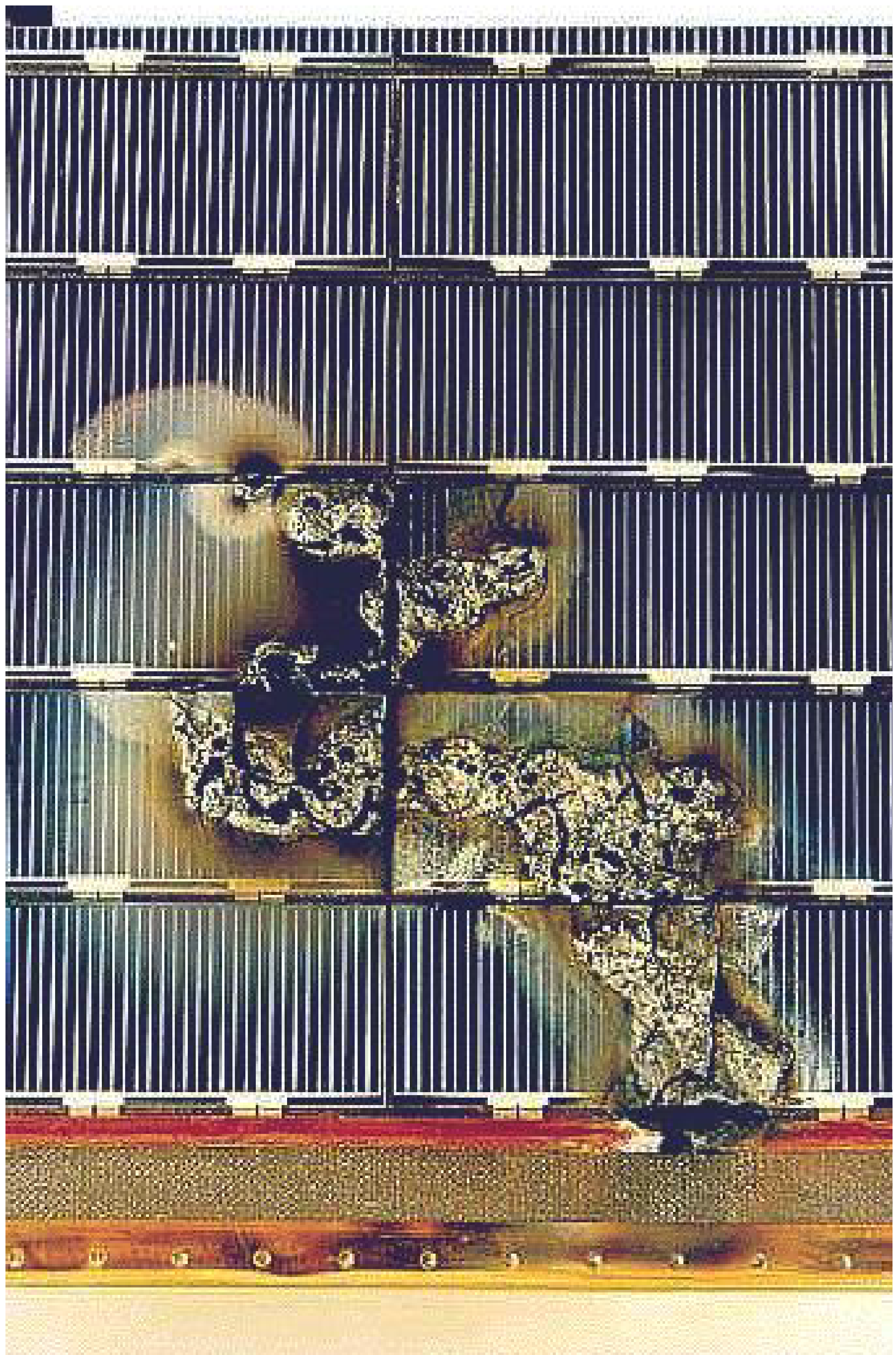

Figure 5 - Sample of flight array from ESA EURECA mission after sustained arcing

Figure 6 – Video frame from EOS-AM1 sustained arc test

Figure 7 – Arc site of sustained arc on EOS-AM1 sample array. Cells are 2x4 cm.

The most famous sustained arc event of all led to the breakage of the TSS-1R electrodynamic tether, and the loss of the attached satellite. Figure 8 shows the burned, frayed and broken tether end still attached to the Shuttle after the break. Incidentally, the tether continued arcing long after it and its satellite were drifting free, until finally it went into night conditions where the electron density was insufficient to sustain the arc. Noel Sargent (2002) has investigated whether the TSS-1R arc was seen to disrupt Shuttle communications. Although he has found no record of disturbed communications during the event, for most of the time the arc was shielded by metallic structures from the communications antennas, and when the tether broke, the arc was many meters from the receiving antennas. It remains to be seen whether sustained arcs produce radio noise severe enough to be a communications problem.

Figure 8 – The end of the remaining TSS-1R tether

When the structure or array capacitance electrically connected to the arc site is sufficiently large, the initial transient arcs themselves can be large enough to produce significant damage. In Figure 9, we see an anodized aluminum plate that has undergone repeated arcing in the laboratory with the ISS structure capacitance attached. Its thermal properties have been completely destroyed, along with most of the insulating surface layer of aluminum oxide.

Figure 9 – Anodized aluminum plate after repeated arcing (Schneider et al, 2002).

4.2.2 EMI

Solar array arcs typically involve the violent discharge of very large currents for very short times. Not surprisingly, the electromagnetic spectrum associated with such discharges obeys the typical power law that has long been observed with arc discharges. We show an example of such a spectrum in Figure 10 (Leung, **19860010269** N). The test article was a small solar array sample that was proposed for a plasma interactions experiment in the Space Shuttle cargo bay. The test was designed to learn whether the radiated EMI from the sample would exceed orbiter specifications. The test was done with the bare array alone and with an added capacitance that simulated the energy storage associated with a full size array. The biasing power supplies were electrically isolated from the arcs by a large resistor. As the curves show, even arcs from a small test array exceed allowed EMI specifications over most of the frequency range. It should be expected that arcing will always produce detectable EMI and that laboratory testing will be needed to quantify the level of interference. The magnitude of radiated EMI is a strong function of the "antenna gain" composed of those conductive (radiating) elements connected to the arc site. This heavily influences the shape of the radiated EMI spectrum (Sargent, 2002). Since antenna gain is extremely difficult to estimate, testing is essential.

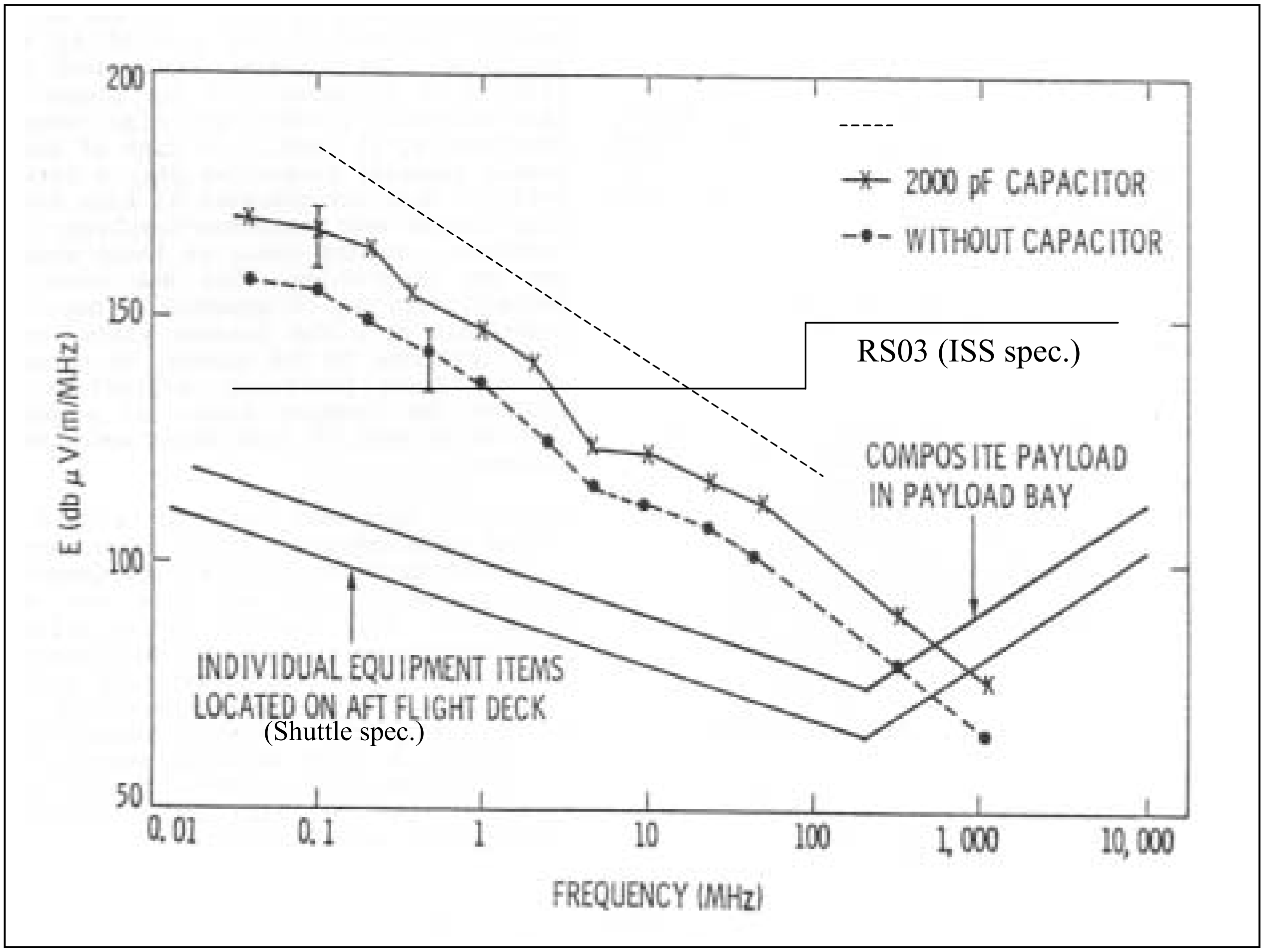

Figure 10 - EMI from a small solar array arc and a hypothetical ISS anodized aluminum arc compared to Orbiter's specs

4.2.3 Structure Arcing

Generally speaking, there are two forms of structure arcing, triple-point arcing, as has been discussed for solar arrays, and dielectric breakdown. For triple-point arcing, insulator must surround a highly negative conductor, and an arc can occur at the conductor-insulator-plasma conjunction. Dielectric breakdown is completely different, and will be discussed below.

An insulator not in the wake in LEO will come through current balance to a potential a few volts less than the plasma potential. If that insulator covers a conductor, the conductor may be at a very different potential (such as the negative floating potential of the spacecraft, for instance). In this case, a thin insulator may undergo dielectric breakdown under the high electric field developed across it. While this may occur for any type of insulator, it is of perhaps greatest interest in the case of anodized aluminum, the main ISS structural element, and a material used in astronaut EMUs (spacesuits). Because the dielectric layer in anodized aluminum is typically very thin (0.1-1 mil) it can break down at potentials of 100 V or less, less than the floating potential that is possible for a 160 V array. It was the arcing threat from the ISS anodized aluminum that forced ISS to incorporate the PCUs to control ISS floating potentials. The PCUs act by creating a large localized plasma cloud that makes good electrical contact with the surrounding plasma, and essentially by brute force grounds the ISS structure to the ambient plasma. A generic plasma-contacting device is called a plasma contactor.

Different samples of anodized material breakdown at different potentials in a plasma (see Hillard et al, 2000). While ISS sulfuric acid anodize withstands about 200 V before breaking down, the chromic acid anodize was found in ground tests to break down at about 72 V. Most disturbing of all, chromic acid anodized samples for astronaut EMUs were found to break down at potentials of only – 60 V, relative to the plasma, with a two-sigma error bar of 10 V. It is thus possible that an astronaut, grounded to ISS by his tether or conductive tools, could undergo an arc at only –50 V. A sneak circuit analysis showed that such arcs could put 1 Amp of current through an astronaut's heart. Since 0.1 Amp is enough to cause heart stoppage, it is imperative that if the ISS plasma contactors are inoperable during astronaut EVAs, a method be used to prevent ISS astronaut workplaces from floating more than 50 V negative.

Dielectric breakdown currents will essentially discharge all surfaces close enough (about 2 meters or so) for the induced plasma cloud to reach. For thin dielectric layers, a few square meters of surface are effectively a capacitor of many microfarads, and can hold several joules of energy, all of which may be discharged in the arc. For many ISS surfaces, peak arc strengths of hundreds of Amps have been calculated. Arcs this strong will melt the arc site and spew molten metal through space. Plasma chamber tests of this kind of arcing are spectacular indeed! Arcs on one anodized surface have been seen to trigger arcs on nearby line-of-sight surfaces.

Very thin dielectric layers will have a low enough resistance that for the purposes of the plasma they would collect current rather than building it up on their surfaces. Thus, while mitigating dielectric breakdown, they must be considered as conductors rather than insulators.

Predicting arc thresholds for thin insulating layers is not as simple as using the published dielectric strengths for insulating materials. It has been found that identical thicknesses of the same anodization may differ by a factor of three or more in arc threshold voltage in a plasma. This may be due to differences in sealing the anodize surfaces, which could affect their resistance to plasma currents. Until the theoretical situation is better understood, plasma testing must be used to determine the dielectric strength of insulators in applications, which could lead to charging in LEO. See Hillard et al, 2000.

Carruth et al (**20000093801**) have found that dielectric breakdown may also be initiated by simulated micrometeoroid strikes at voltages as low as 55 V.

4.2.3.1 The Continuous Arc (Sustained Arc)

Arcs that occur in air when electrical contacts are made or broken are due to breakdown of the neutral gas. While these may become continuous ("showering arcs") they are not the same phenomenon as the continuous arcs in a LEO environment, which involve breakdown of the gas liberated by the arc itself. (See Holm, 1999, for a discussion of continuous arcs in air).

When the LEO arc circuit includes the solar arrays, distribution cabling or other source of power, it may be possible for structure or solar array arcs to become continuous (or sustained). Such continuous arcs, fed by the power supply, have an essentially inexhaustible source of energy, and can lead to catastrophic damage. This hypothesis for the loss of solar array strings on the SS/Loral satellites PAS-6 and Tempo II was confirmed by ground-tests done by Snyder et al (2000). Later testing on the EOS-AM1 arrays showed that continuous solar array arcs could occur in a LEO environment at a string voltage as low as 100-120 V. (In those tests, the sustained arc occurred at a voltage relative to the surrounding plasma of –250 V.) The most recent data (Vayner et al, 2003) have shown that strings with potentials as low as 40 V with respect to each other can lead to sustained arcing. The scenario for the catastrophic loss is given in Ferguson et al (1999), and is summarized here:

First of all, an ordinary solar array arc must get started. This will usually be at a triple-point as described above. In the case of the SS/Loral arrays, the differential voltage between solar array and plasma could have been as low as 100 V, for the SS/Loral arrays were using thin coverslides similar to the APSA cells, which arced at voltages as low as 75 V on orbit (PASP Plus results, Soldi et al, **19960024017**).

When the initial arc (sometimes called the trigger arc) is generated, it discharges only the local capacitance, but the arc plasma expands out from the arc site and comes in contact with an exposed conductor at a very different voltage. In the case of the SS/Loral arrays, the most positive end of the array strings was less than a millimeter away from the negative end. Now the arc plasma makes direct contact with the other conductor and makes for an almost dead short to that spot. The arc current has changed from one that is discharging capacitance to a current between two ends of the solar array string.

If the current available to the arc site from the functioning arrays is greater than a certain threshold value (believed to be about 1/2 Amp) and the voltage between strings is above a certain value (believed to be about 40 V), the arc may become continuous. In ground tests these arcs continued until the source of power was artificially turned off. In space, presumably the arc would continue until the exposed conductors were melted through and the circuit was thereby interrupted. This could take seconds or minutes. Ground tests have shown that an arc that persists for more than a few hundred microseconds will not shut off by itself.

An arc that lasts long enough will locally heat the substrate and release gases. In the case of a Kapton® substrate, the Kapton® chars, but the char is also a good conductor, and provides a path for the arc to continue. Snyder et al (2000) have shown that the heat generated in continuous arcs on Kapton® is sufficient to produce the Kapton® charring measured after the event.

In any event, a continuous arc can destroy a whole string (if the arc is between traces on the same string) or adjacent strings (if the arc is between strings) or the entire array power (if the arc is between combined power traces). The possibility of losing the entire array power on the Deep Space 1 mission caused the builders to remove a solar panel that had already been installed to modify it and its sister array to prevent continuous arcing. Its power traces were only a few millimeters apart, and were exposed both to the plasma and to each other before the modifications were made. Afterwards, insulating material prevented arc plasma from shorting out between the power traces.

Anodized aluminum structure elements may be subject to continuous arcing if the arc plasma generated can contact the solar array or other power source or if the potential at the arc site can be maintained at a high enough negative level by a high voltage electron-collecting power source. Such continuous anodized breakdowns were called "sizzle arcs" by the team that discovered them (Murphy et al, 1992).

Finally, an arc on an electrodynamic tether may become continuous. The infamous arc on the TSS-1R tether that led to its break and the loss of the satellite was a continuous (sustained) arc with its power supplied by the tether. The arc site was a flaw in the tether insulation that spewed gas out which became ionized and completed the arc circuit path (Szalai et al, **19970011947** N, Vaughn et al, **19970021635** N). Since in this case the power source was more one of constant voltage, rather than constant current, the 3500 volt potential difference between the tether top and bottom caused the arc site to float at just the negative potential (about –600 V) necessary to keep the arc going and still collect the ~1 Ampere arc current of electrons on the satellite. Had TSS-1R used a tether of greater resistance, the threshold arc current could not have been maintained. For example, a total tether resistance of ten thousand ohms would have limited the arc current to less than 0.4 Amps, less than the sustained arc threshold. Alternatively, if the satellite electron collection capability had been limited to less than ½ Amp, the arc could not have been sustained. Of course, these measures would have severely restricted the power or propulsion that could be obtained by tether operation and could not be tolerated on an experiment that was not just a proof-of-concept. An arc detection circuit could have also been used to shut the tether down at the satellite end when very large currents were first detected. One should never assume that a high voltage power system will not arc.

5.0 MITIGATION TECHNIQUES

5.1 Current Collection

If a spacecraft has no exposed high voltage conductors, it will not collect much current. That is, insulation or encapsulation is a valid technique for preventing current collection in LEO. The GEO Spacecraft Charging Guidelines (Purvis et al, 1984) recommend coating spacecraft surfaces with conducting materials to keep all surface potentials the same and reduce differential charging. In LEO, however, the space plasma will act to keep insulating surfaces at the same potential (discounting wake effects), so conductive coatings are not needed. If encapsulation or insulation is not possible, hiding conductive surfaces (like the edges of solar cells) from the ambient plasma by use of narrow spacing of overlying insulators (like coverslides) may choke off most current collection. It has often been remarked that if the ISS solar arrays had just a little more coverslide overhang and/or a little tighter cell spacing there would never have been an issue with ISS charging. Of course, if all high voltage components are inside a sealed pressure vessel, they cannot collect current from the ambient plasma.

Encapsulation (or grouting with RTV) of solar arrays has been shown to be an effective method to prevent electron collection and charging (Reed et al, 2001). One must be careful with the use of encapsulants, however, when the possibility exists of outgassing in the presence of high voltage components. For instance, on SAMPIE, one of the high voltage power supplies was destroyed by a Paschen discharge that occurred on a high voltage component where the encapsulant had delaminated and a neutral pressure was enclosed with the high voltage component (Ferguson and Hillard, 1997, and see Figure 11 for Paschen curves). On TSS-1R, the ”trigger arc” was a Paschen discharge due to entrained gas inside the tether pulley casings (Szalai et al, **19970011947** N, Vaughn et al, **19970021635** N). In this case, a flaw in its insulation exposed the tether conductor.

Placing plasma current collecting conductors into the wake of a large spacecraft is an effective technique for preventing current collection. On ISS, for instance, FPP data showed that when the arrays were turned into their own wakes, they collected such a small amount of electron current that the ISS structure would not charge. On ISS, this technique of wake-pointing the arrays is now used as a backup for the Plasma Contacting Units during astronaut EVAs. Of course, very high potentials on wake-pointing conductors may collapse the wake, but this will require thousands of volts potential for large structures.

For a spacecraft that will often undergo auroral passage, one must be careful with the use of insulators. Like in GEO, spacecraft in the aurorae can undergo rapid differential charging on insulators, and this can lead to buildup of potentials that might lead to arcing. It is hoped that a subsequent document will cover polar-orbiting spacecraft in the detail this document covers equatorial LEO orbits.

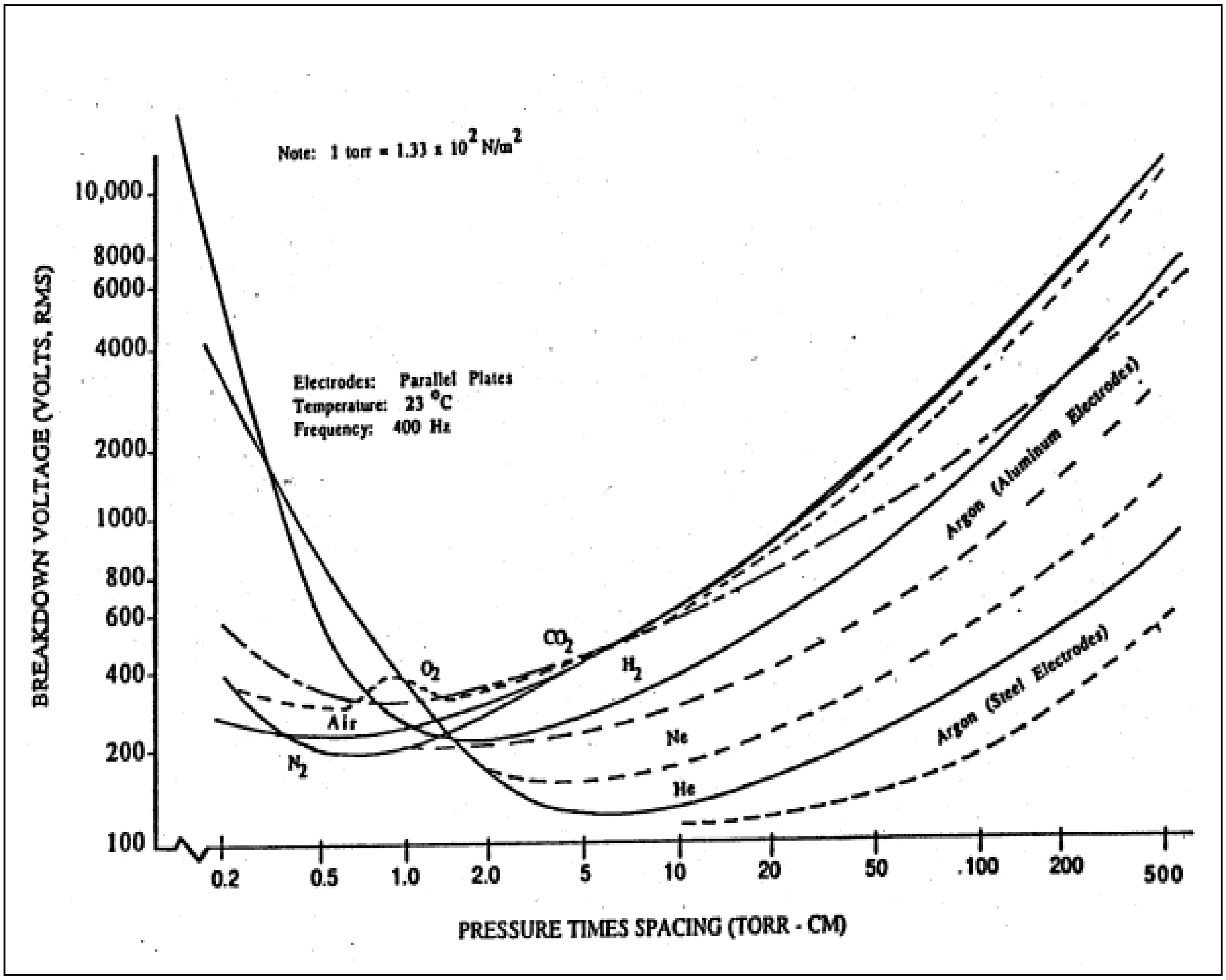

Figure 11 - Voltage Breakdown of Pure Gases as a Function of Pressure Times Spacing

5.2 Controlling Spacecraft Potential

There are three basic techniques to control spacecraft potential. One is to place the structure at the most positive potential generated by the LEO spacecraft power system (the positive ground option) The second is to ground the structure by brute force to the ambient plasma (the plasma contactor solution). Thirdly, one can prevent any plasma exposure of high voltage conducting surfaces (the encapsulation solution). We will discuss these mitigation strategies in order below. For ideas about other ways to prevent spacecraft charging, see Ferguson, 2002.

5.2.1 Positive Ground

Since charging in LEO is dominated by current collection on the most positive end of the solar arrays, and the negative end floats at about 90% (typically) of the string voltage, the positive end of the array will be at about 10% of the array string voltage away from the plasma potential. For a 160 V array, this means a positively grounded structure will float at 16 V or less away from the plasma potential. Most deleterious plasma effects are minimal at such a potential. In fact, the structure in this case contributes to electron collection, and will actually float closer to plasma potential than the positive end of the array will, taken alone, due to exposed grounded conductors on the structure.

However, most spacecraft power systems are negatively grounded because of a dearth of space qualified electronics with the positive ground polarity. Although very efficient PMAD systems now exist that use buck-boost converters to change the ground polarity and voltage (Button et al, **20020038857**), most spacecraft busses do not incorporate this technology yet.

For instance, when ISS charging possibilities were first being considered, it was estimated that to change the power system ground from negative to positive would cost at least $100 M. It was decided instead to use the plasma contactor mitigation strategy detailed below, which ended up costing less than $35 M.

A variant of this technique uses a center-tapped array, but will only cut the maximum structure potential to about half of the solar array string voltage.

5.2.2 Plasma Contactors

A device that makes good contact with the surrounding plasma can effectively ground its point of contact. If the device is a large sheet of metal, it will dominate current collection and stay near plasma potential. However, the sheet of conductor must be much larger than the solar array effective electron collecting area for this solution to work. In the case of ISS for instance, the metal sheet would need hundreds or thousands of square meters of ram ion collecting area to be effective. In LEO, the drag produced by such a large area would be prohibitive.

Electron guns were used on PIX-II (Purvis, 1985) and PASP Plus (Guidice and Severance, **19980017264**) to emit the electrons being collected by high voltage solar arrays and thus prevent charging, but such devices are limited by space charge considerations to low emitted electron currents. A better solution is a device that is not limited by space charge considerations, i.e. a plasma contactor.

A plasma contactor generates a high-density plasma cloud, which expands and makes good electrical contact with the ambient plasma. Usually a hollow cathode device (Davis et al, **19870026810** A) is used to emit a xenon plasma, whose space charge is nullified by nearly equal densities of electrons and ions in the emitted cloud. The very mobile electrons carry current into the surrounding ambient plasma. This current can be very large. For instance, the ISS PCU device has a hollow cathode element smaller than a little finger, but can emit up to 10 Amps of continuous electron current. In the case of ISS, the PCU acts like a ground rod at its location to effectively ground (to within about 20 V), the structure to the ambient plasma. Of course, at other points, the structure will still have the $\vec{v} \times \vec{B} \bullet \vec{l}$ potential away from the ambient plasma. This is only 40 V from end to end on the largest structure ever orbited (i.e. ISS), so at all points the potential is outside the arcing range (- 50 V or less).

While a hollow cathode plasma contactor requires xenon gas vessels, refurbishment, etc., other devices with little or no expellant are being explored for use as plasma contactors. As an example, a plasma contactor made of microtips and microscopic holes, with an imposed bias, could theoretically emit electrons over a wide area and thus defeat the space charge limitation with no working gas. A patent has been awarded for using such a device to control spacecraft potentials in GEO (Katz, 2001, U.S. Patent # 6,177,629) but making such a device work reliably in the high density plasma of LEO is no small feat and has not yet been done.

5.2.3 Encapsulation

Encapsulating the high voltage conductors on solar arrays, etc., can have a twofold beneficial effect. First, it can prevent arcing at triple-points by keeping the plasma away from the conductor-insulator junctions. Secondly, it can prevent electron collection by the arrays, and thus prevent spacecraft charging at its root cause. So far, the only arrays ground-tested in a simulated LEO plasma to withstand bias voltages greater than 300 V have been those with the arrays or cells encapsulated (Reed et al, 2001, Ferguson and Vayner, 2002, Brandhorst and Best [**20010056310**]).

When encapsulating arrays or cells, several caveats must not be ignored. First, no air must be entrained anywhere. While this may seem obvious, at least one set of encapsulated test arrays sent to NASA's Glenn Research Center had sufficient air entrained that the coating delaminated and swelled under vacuum. In fact, so much air was entrained that the test articles under vacuum appeared to swell up like plastic balloons. In cases where only a very small amount of air is trapped, visible effects may not occur, yet the trapped air will present the danger of Paschen breakdown under high voltage (see Figure 11).

Second, the encapsulant thickness must be sufficient to withstand dielectric breakdown at the highest array voltage. For thin-film arrays, this consideration can contribute significantly to the array mass. In keeping with the discussion we had under structure arcing, it is important that thin-film encapsulants be tested under voltage in a plasma environment, rather than relying solely on published dielectric strengths.

Third, the encapsulant must not be able to peel away from high voltage components, or Paschen breakdown can occur due to entrained outgassing products that may reach sufficiently high neutral pressures. Figure 11 (Dunbar, 1988) shows the Paschen breakdown curve for a number of gases for DC to low frequency AC (~ 400 Hz) for parallel plates. Here it can be seen that for a wide range of pressure distance combinations, the Paschen minima are typically around a few hundred volts for common gases. Helium gas has the lowest Paschen minimum voltage. Most outgassing products have not had their Paschen curves measured. In the case of solar arrays, a coverglass that covers many cells must also make allowances for escape of outgassing products from adhesives, as well. It must be treated for all intents and purposes as a vented enclosure (treated below).

Fourth, the encapsulant must be able to withstand other aspects of the space environment for its design lifetime. Atomic oxygen, micrometeoroids and debris, and UV and X-ray exposure are some of the threats to the encapsulant. Glass stands up well to all of these environments. Some plastics do not.

5.2.3.1 Vented enclosures

It should be pointed out that the use of a sealed pressure vessel eliminates environmental interactions and this applies to plasma interactions as well. In the more general case, high voltage systems other than solar arrays are usually contained in a vented enclosure. To avoid plasma interactions, care must be taken that plasma does not enter the enclosure and react with exposed conductors inside. The key requirement on such systems is that all openings must be smaller than the plasma Debye length, which depends on the plasma density and temperature. One can readily estimate the maximum opening consistent with such a requirement.

The plasma will be capable of maintaining electric fields over a distance of approximately one Debye length λ_D, which is given by

$$\lambda_D = (kT_e/4\pi ne^2)^{1/2} = 7.43 \times 10^2 (T_e/n)^{1/2} \qquad (5.2.3.1)$$

where T_e is the electron temperature in eV, k is the Boltzmann constant, $\pi = 3.14159...$, e is the charge of the electron, and n is the electron density in cm^{-3}. Placing representative values from International Reference Ionosphere (IRI-86) simulations in the above equation, one finds a minimum Debye length from 0.12 cm at 1100 K to 0.17 cm at 2300 K.

Openings in the experiment electronics enclosure must have smaller dimensions than this minimum to prohibit plasma interactions with the experiment electronics. Larger openings may be used if covered with an electrically connected conductive wire mesh of spacing less than the minimum Debye length. To provide a reasonable margin of safety, a general guideline is that no opening should exceed 0.10 cm in its largest dimension.

5.3 Arcing

5.3.1 On-orbit Arc Detection

Usually when ground-testing solar arrays under simulated LEO plasma conditions, and especially when the array may undergo sustained arcing, an arc detection circuit is employed. It essentially looks for a rapid positive change of the array or arc site potential toward the plasma potential, as this must happen when electrons are emitted during an arc. Conversely, one can sense the emission of copious electrons and use this for arc detection. Further, the broadband EMI from an arc can be used for arc detection. In any event, electrical detection techniques can unambiguously detect an arc when it occurs. Then, in the ground tests, the power supply is electrically disconnected from the array, to prevent the occurrence of sustained arcs that might damage or destroy the sample. Sometimes, the power supply is only disconnected when the arc continues for longer than 200 ms, for example, so that arcs that would be permanently sustained can be counted, but are not allowed to wreak their damage on the sample. Such arc detection and array protection circuits can be built and used on solar arrays operating on-orbit. If this is done, rather than totally preventing arcs, the damage they can do to the arc site can be limited or prevented. In this way, one can perhaps live with the arcs that do occur.

It must be obvious that the power to the LEO spacecraft will be interrupted whenever the array arc-circuit is broken. Rather than being the first line of defense against arcing, arc detection and array shunting must only be used when the disruptions they cause will be infrequent.

5.3.2 Prevention Techniques

The design of a solar array must consider the plasma environment and interactions with that environment. Arc prevention is extremely important. The following techniques have been shown in ground and flight tests to prevent arcs or minimize their damage:

1. If possible, use array string voltages of less than 55 V. No trigger arcs have been seen on LEO arrays of less than about 55 V string voltage even under simulated micrometeoroid bombardment. Solar arrays coming out of eclipse will generate more voltage than when they operate at their max power point.

2. If solar array cell edges or interconnects are exposed to the LEO plasma and string voltages are greater than 55 V, the strings should be laid out on the substrate such that no two adjacent cells have a voltage difference of greater than 40 V. Sometimes a leapfrog arrangement will be sufficient. In other high voltage arrays, the strings should be arranged parallel to each other. Serpentine strings can be used to prevent the array width from becoming prohibitive. If the string layout cannot be modified to prevent cells with more than 40 V difference being adjacent to each other (anything less than about 1 cm may be considered adjacent) then the total string voltage must be kept low enough that the initial (trigger) arcs do not take place. The lowest known array trigger arcing has occurred on thin-coverglass cells at about 75 volts (Soldi et al, **19960024017,** PASP Plus results).

3. For array string voltages greater than about 75 V, trigger arcs in LEO can only be completely prevented by encapsulating the cell or array edges so they do not see the ambient plasma. The caveats mentioned above under “Encapsulation”, section 5.2.3, must be followed. If encapsulation is not possible, a thorough array bakeout on-orbit (1 week at 100 C or more) may get rid of contaminants and prevent trigger arcing up to about 300 V, or possibly more (see Vayner et al, 2002). Re-contamination may occur on “dirty” spacecraft (spacecraft with excessive venting, cold gas nozzles, etc.). Good encapsulation may prevent arcing up to 1000 V string voltage.

4. Sustained (or continuous) arcs may occur whenever trigger arcs occur and adjacent cells have more than 40 V potential differences. However, sustained arcs, in addition to this voltage threshold, have a current threshold, below which they will not occur. It is believed that the current threshold is greater than about 0.5 Amp. If the current produced by each cell is above this threshold, a single string may sustain arcs. If each cell is below this current threshold, then isolating separate strings of solar cells from each other will prevent other strings from “feeding” the arc site, and will prevent sustained arcs. This isolation can be achieved by using blocking diodes in each string (EOS-AM1, now called Terra, e.g. Snyder, 2000, for instance). Care must be taken that the power bus and/or other components do not have the conditions necessary for

sustained arcing. On the Terra arrays, for instance, it was found that diodes used to block interstring currents did not prevent the bus power traces from having sustained arcing events. Covering all exposed bus conductors with Kapton® insulation finally solved the problem. Low-outgassing RTV may be used to cover bare conductors as well.

5. RTV grout between adjacent solar cells and strings that have a high voltage with respect to each other has been shown to effectively block sustained arcs between cells and strings. The degree of coverage, etc., is important in determining the final voltage threshold for sustained arcing.

6. Arrays of 300 V and greater string voltage must be fully encapsulated in order to prevent arcing. Caveats involved under "Encapsulation" (Section 5.2.3) above must be followed.

7. Finally, although design and construction are important in preventing trigger arcs and sustained arcs, each new solar array implementation must be tested in a simulated LEO plasma before it can be sure not to arc. This step must not be omitted. The test bias voltage relative to the plasma should include the maximum when the arrays come out of eclipse (or the highest potential expected on the "floating" spacecraft). The interstring voltage should be at least as great as that expected anywhere on the solar array on-orbit. Tests should ideally be conducted at sample temperatures as low as the eclipse-egress temperature.

6.0 MODELING

6.1 Spacecraft Charging

The severity and widespread nature of plasma interactions have led to a considerable investment in the development of computer models. There are many empirical and semi-empirical models available with varying levels of capability and fidelity. Since the physics of current collection is fully embodied in Poisson's equation, a first-principles treatment is both possible and practical. The most comprehensive such code available at this time for LEO is NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit). This code was developed as a follow-on to the original NASCAP program that dealt with spacecraft charging in geosynchronous orbit (see refs. 19810019598, 19820017934, and 19840018141, for example).

A finite element-based solver, NASCAP/LEO reasonably approximates the geometry of sophisticated satellites or subsystems. With an expandable materials database, it iteratively solves for the potentials on all surfaces and electric fields in nearby space. The existing code was designed for mainframe and workstation deployment, makes many approximations necessitated by the limited desktop computing power of the mid 1980's, and has a reputation for having a steep learning curve. It is nevertheless credited with considerable success and in the hands of a skilled user is powerful and reliable.

A new version, currently being developed in conjunction with the US Air Force, called NASCAP-2K, is now available. However, the LEO portion of the code will become available during the fall of 2003. NASCAP-2K incorporates lessons learned over the past 18 years, takes full advantage of modern computing power with much more sophisticated algorithms, and is designed to be easier to use. Capable of modeling current collection and charging under LEO, GEO and auroral conditions, NASCAP-2K will soon supersede both NASCAP and NASCAP/LEO. See Neergard et al, **20010059345.**

Of special interest here is a computer-modeling tool called EWB (the Environments WorkBench, see Chock and Ferguson, 1997). This tool, which can run on a desktop or laptop PC, uses simple models of plasma environments and interactions to predict LEO spacecraft floating potentials, for example. Over 100 models of the LEO environment are included in this integrated code, and over 50 interactions models, including the plasma interactions models considered here. EWB was extensively funded by the ISS and is the official ISS plasma interactions tool. Detailed and extensive models of various ISS configurations are included with EWB, although the code can also be used to create and model a wide variety of different LEO spacecraft. Both EWB and NASCAP-2K are subject to ITAR restrictions, and at present cannot be given to non-US citizens. For more information on distribution of these codes, please see http://see.msfc.nasa.gov.

6.1.1 An Example

In Figure 12 is a plot showing the result of an EWB calculation of potentials on the ISS mission build 12A. Here, a special model of ISS solar array current collection and ISS solar array mast wire current collection, based on PCU measurements of previous ISS mission builds, was constructed by SAIC. The potentials shown were determined by iteration until the current balance equation was satisfied for ISS as a whole. In this figure, the PCUs were turned off, to investigate charging under PCU failure conditions. It is clear that for this configuration, most of the vehicle charging is due to $\vec{\mathrm{v}} \times \vec{B} \bullet \vec{\mathrm{l}}$ effects across the long truss and solar array segments. Not shown are the EWB screens that detail the potentials and currents on each ISS component. EWB can also easily calculate the time dependence of all of the ISS potentials during an orbit and their dependencies on plasma parameters and changes in the detailed ISS configuration. Of course, EWB can also be used for other spacecraft. Figure 12 just illustrates how complex a system can be analyzed with this extremely useful computer code.

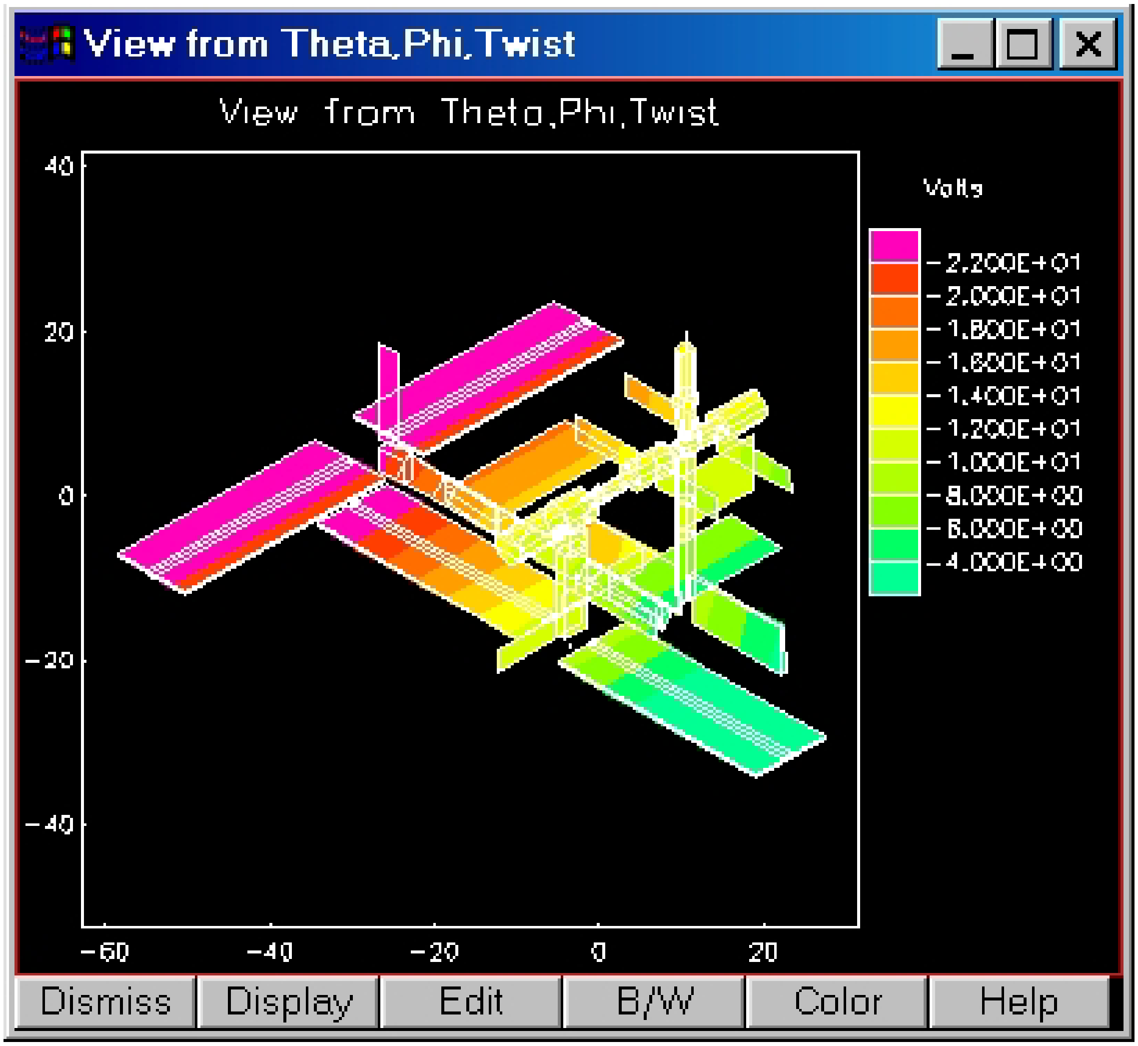

Figure 12. An EWB contour plot of ISS potentials. This is the 12A mission configuration at an arbitrary point in the orbit. The deviation from front to back in the picture is due to $\vec{v} \times \vec{B} \bullet \vec{l}$ effects.

6.2 Arcing

The process of electrical breakdown has not lent itself well to modeling and solar arrays are no exception. The above-mentioned computer codes for determining potentials on all surfaces and electric fields in nearby space are certainly useful for solar arrays, but the actual initiation of an arc is extremely difficult to predict. Despite NASA's efforts to fund theoretical work in this area during the 1990's no reliable model for arc initiation exists. Experience has shown that that knowledge of the potential distribution is at best a rough indicator of the probability of an arc. The complex geometries involved in cell construction and string layout along with the poorly understood properties of adhesives, coatings, and other materials often result in laboratory tests behaving in unexpected ways. This emphasizes the need for testing of solar arrays in suitable space environmental chambers and ultimately as part of space experiments.

7.0 TESTING

The importance of testing in mitigating LEO spacecraft charging and its effects cannot be overestimated (see Ferguson, 1996). A valid LEO arc test must take place in a vacuum of pressure less than 10 microtorr. It must generate a plasma with an electron density of more than 10^5 electrons per cubic centimeter. The electron temperature must be less than about 3 eV, and the plasma should not be a streaming plasma (it should be essentially isotropic). The sample temperature must be as low as the lowest sunlit temperature on orbit. To ensure that arcs will not occur in space, a sufficiently long waiting time must be used at each bias voltage that the arc rate is measured to be statistically significantly lower than the threshold arc rate. If the threshold is unknown, see Ferguson (**19860018653** N) for a proper technique for establishing it in ground tests. Be aware that the arc rate at a given voltage usually decreases with time in the plasma – do not confuse this with an increasing arc voltage threshold (see Ferguson, **19860018653** N). The chamber used for the tests should be big enough that the plasma sheath of the biased sample does not reach the chamber walls. Finally, use solar array design and building techniques that have been space qualified, whenever possible.

In LEO plasma testing, the array or anodized aluminum potential relative to the plasma (which in space is due to spacecraft charging) is usually obtained by biasing the sample with a DC power supply. If one is interested in investigating transient arcs, one must decouple the DC power supply from the arc current during an arc. This means the bias supply circuit must have a time constant greater than a few hundred microseconds, so the arc can build up and dissipate without being powered by the bias supply. This can be done by putting a large resistance in the arc circuit, and incorporating a capacitor to simulate the array or structure capacitance that would be discharged in the arc. For instance, if the on-orbit capacitance connected to the arc site is expected to be 0.1 microfarad, then this value capacitor can be used to provide current during the arc. With such a capacitor, the bias supply circuit can be given a 1-millisecond RC time constant (much greater than the arc time scale) by using a 10 kΩ series resistance. This effectively decouples the bias power supply from the arc. Of course, it also puts an upper limit on the arc rate attainable, because of recharge time considerations.

If doing non-destructive sustained arc testing, the series resistance should be adjusted to limit the maximum current to that expected in the arc, and a cutoff circuit should be employed to shut off the bias supply after a few hundred microseconds. Experience shows that an arc that continues under such circumstances for more than about 200 microseconds will be sustained. Arc current and/or voltage waveforms should be closely monitored to distinguish between transient and sustained arcs. Videotapes of arc locations are helpful for diagnostic purposes. If destructive sustained arcs are allowed to occur, the videotape can confirm the arc time duration.

References not in CASI

Chen, F.F., 1965. “Electric Probes,” in Plasma Diagnostic Techniques, R.J. Huddlestone and S.L. Leonard, eds., Academic Press, pp. 113-200.

Chock, R.C., 1991a. “NASCAP/LEO Simulations, SSF Solar Cell Geometries,” Minutes of the Electrical Grounding Tiger Team Meeting, Boeing Trade Zone, Huntsville, Alabama, May 14-17.

Chock, R., 1991b. “NASCAP/LEO Simulations of Shuttle Orbiter Charging During the SAMPIE Experiment,” Fifth Annual Workshop on Space Operations, Applications, and Research (SOAR ’91), Houston, July 9-11, NASA CP 3127, p. 655.

Chock, R. and Ferguson, D.C., 1997. "Environments Workbench – An Official NASA Space Environments Tool," Proceedings of the 32nd Intersociety Energy Conversion Engineering Conference, Wash. DC, Paper IECEC-97452, pp.753-757.

Dunbar, W.G., “Design Guide: Designing And Building High Voltage Power Supplies,” Air Force Wright Aeronautical Laboratories AFWAL-TR-88-4143, Volume II, 1988.

Ferguson, D.C., 1996. “The Role of Space Plasma Simulation Chambers in Spacecraft Design and Testing,” 31st Intersociety Energy Conversion Engineering Conference Proceedings, Institute of Electrical and Electronics Engineers, pp. 2188-2192.

Ferguson, D.C. and Hillard, G.B., 1997, “Lessons for Space Power System Design from the SAMPIE Flight Experiment,” AIAA Paper # 97-0087, 35th Aerospace Sciences Meeting and Exhibit, Reno, NV, January 6-10.

Ferguson, D.C., Hillard, G.B., Snyder, D.B., and Grier, N.T., 1998. “The Inception of Snapover on Solar Arrays: A Visualization Technique,” AIAA Paper #98-1045, 36th Aerospace Sciences Meeting and Exhibit, Reno, NV, January 12-15.

Ferguson, D.C., Snyder, D.B., Vayner, B.V. and Galofaro J.T., 1999. “Array arcing in orbit - From LEO to GEO,” AIAA Paper #99-0218, 37th Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan. 11-14.

Ferguson, D.C. and Gardner, B., 2002. “Modeling International Space Station (ISS) Floating Potentials,” AIAA Paper #2002-0933, 40th Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan. 14-17.

Ferguson, D.C., 2002. “Alternatives to the ISS Plasma Contacting Units,” AIAA Paper #2002-0934, 40th Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan. 14-17.

Hastings, D.E., 1995. "A review of plasma interactions with spacecraft in low Earth orbit," Journal of Geophysical Research, vol. 100, No. A8, pp.14457-14483.

Hoeber, C.F., Robertson, E.A., Katz, I., Davis, V.A., and Snyder, D.B., 1998. "Solar array augmented electrostatic discharge in GEO," AIAA Paper #98-1401, International Communications Satellite Systems Conference and Exhibit, 17th, Yokohama, Japan, Feb. 23-27.

Holm, R., 1999. **Electric Contacts: Theory and Applications, 4th ed.**, Springer Verlag.

Hillard, G.B., Bailey, S.G., and Ferguson, D.C., 2000, "Anodized Aluminum as Used for Exterior Spacecraft Dielectrics", 6th Spacecraft Charging Technology Conference, AFRL-VS-TR-20001578, pp. 111-113.

Katz, Ira, 2001. Spacecraft solar array charging control device. U.S. Patent # 6,177,629.

Murphy, G., Croley, D., Ratliff, M., and Leung, P., 1992. "The Role of External Circuit Impedance in Dielectric Breakdown," AIAA Paper # 92-0821, 30th Aerospace Sciences Meeting and Exhibit, Reno, NV, January 6-9.

Purvis, C.K., 1985. "The Pix-II Experiment: An Overview," Spacecraft Environmental Interactions Technology 1983, NASA CP-2359, AFGL-TR-85-0018, pp. 321-332.

Purvis, C.K., Ferguson, D.C., Snyder, D.B., Grier, N.T., Staskus, J.V., and Roche, J.C., 1986. "Environmental Interactions for Space Station and Solar Array Design – Preliminary," NASA Lewis Research Center.

Reed, B.J., Harden, D.E., Ferguson, D.C., and Snyder, D.B., 2001. "Boeing's High Voltage Solar Tile Test Results," 17th Space Photovoltaic Research and Technology Conference, Ohio Aerospace Institute, September 11-13.

Sargent, Noel B., 2002. Private communication.

Schneider, T., Carruth, M.R., and Hansen, H., 2002. "ISS Plasma Interactions Arc Testing at MSFC," Powerpoint Presentation, NASA ISS TIM, JSC, March 12.

Snyder, D.B., 1995. "Dynamic Interactions Between Ionospheric Plasma and Spacecraft," Radio Science Bulletin, #274, September, p. 29.

Snyder, D.B., Vayner, B.V., and Ferguson, D.C., 1998. Private communication.

Snyder, D.B., Ferguson, D.C., Vayner, B.V., and Galofaro, J.T., 2000. "New Spacecraft-Charging Solar Array Failure Mechanism," 6th Spacecraft Charging Technology Conference, AFRL-VS-TR-20001578, pp. 297-301.

Vayner, B.V., Galofaro, J.T., and Ferguson, D.C., 2003. “Interactions of High-Voltage Solar Arrays with Their Plasma Environment: Ground Tests,” in publication.

APPENDIX A

Glossary OF TERMS

*Based on AFWAL-TR-88-4143 Vol. 2

Aging	The change in properties of a material with time under specific conditions.
Ambient Temperature	The temperature of the surrounding cooling medium, such as gas or liquid, which comes into contact with the heated parts of the apparatus.
Anode	The electrode through which a direct current enters the liquid, gas, or other discrete part of an electrical circuit. The positively charged pole of an electrochemical cell.
Anti-Oxidant	Substance that prevents or slows down oxidation of material exposed to air.
Arc-over Voltage	The minimum voltage required to create an arc between electrodes separated by an insulating medium under specified conditions.
Arc Resistance	The time required for an arc to establish a conductive path in a material.
Bond Strength	The measure of adhesion between bonded surfaces.
Breakdown (Puncture)	A disruptive discharge through an insulating medium.
Breakdown Voltage	The voltage at which the insulation between two conductors fails.
Capacitance (Capacity)	That property of a system of conductors and dielectrics that permits the storage of electricity when potential difference exists between the conductors. The ratio of the charge on one of the conductors of a capacitor (there will be an equal and opposite charge on the other conductor) to the potential difference between the conductors.
Capacitor - (Condenser)	A device where the primary purpose of which is to introduce capacitance into an electric circuit.
Cathode	The electrode through which an electric current leaves a liquid, gas, or other discrete part of an electric circuit; the negatively charged pole of an electrochemical cell.

Cell	A single unit capable of serving as a d-c voltage source by means of transfer of ions in the course of a chemical reaction.
Charge	In electrostatics, the amount of electricity present upon any substance which has accumulated electric energy.
Conductance	The reciprocal of resistance. It is the ratio of current passing through a material to the potential difference at its ends.
Conductivity	Reciprocal of volume resistivity. Conductance of a unit cube of any material.
Conductor	An electrical path that offers comparatively little resistance. A wire or combination of wires not insulated from one another, suitable for carrying a single electric current.
Contaminant	An impurity or foreign substance present in or on a material which affects one or more properties of the material
Corona	A non-self sustaining discharge (sometimes visible) due to ionization of the gas surrounding a conductor around which exists a voltage gradient exceeding a certain critical value for a gaseous medium.
Corona resistance	The time that insulation will withstand a specified level of field-intensified ionization that does not result in the immediate complete breakdown of the insulation.
Creep	The dimensional change with time of a material under load.
Creepage (electrical)	Electrical leakage on a solid dielectric surface.
Creepage surface on path	An insulating surface that provides physical separation as a form of insulation between two electrical conductors of different potential.
Critical Voltage (of gas)	The voltage at which a gas ionizes and corona occurs, preliminary to dielectric breakdown of the gas.
Delamination	The separation of layers in a laminate through failure of the adhesive.
Dielectric	A non-conducting material whose conductivity is much smaller that 1.
Dielectric Absorption	The persistence of electric polarization in certain dielectrics after removal of the electric field.
Dielectric Constant (relative permittivity)	Property of a dielectric, which determines the electrostatic energy stored per unit volume for unit potential gradient.

Dielectric Loss	The time rate at which electric energy is transformed into heat in a dielectric when it is subjected to a changing electric field.
Dielectric Strength	The maximum electrical potential gradient (voltage) that an insulating material can withstand without rupture; usually expressed in Volts in per mm of thickness.
Dielectric Test	Tests which consist of the application of a voltage higher than the rated voltage for a specified time for the purpose of determining the adequacy against breakdown of insulating materials and spacings under normal conditions.
Disruptive Discharge	The sudden and large increase in current through an insulation medium due to the complete failure of the medium under the electrostatic stress.
Electric Field Intensity	The force exerted on a stationary positive charge per unit charge at a point in an electric field. Designated by E. Also known as electric field strength, electric field vector. For a point charge in space, it is given by $E = \dfrac{Q}{4\pi\varepsilon r^2}$ where r is the distance from the charge Q and ε is dielectric constant.
Electrode	A conductor, not necessarily metal, through which a current enters or leaves an electrolytic cell, arc, furnace, vacuum tube, gaseous discharge tube, or any conductor of the non-metallic class.
Electron	A stable elementary, negatively charged particle that circles around the center or nucleus in an atom.
Encapsulating	Enclosing an article in a closed envelope of plastic or other sealant.
Epoxy Resins	Straight-chain thermoplastics and thermosetting resins based on ethylene oxide, its derivatives or homologs.
Filler	A substance often inert added to a plastic to improve properties and/or decrease cost.
Flammability	Measure of the material’s ability to support combustion.
Flashover	A disruptive electrical discharge around or over the surface of a solid or liquid insulator.
Floating Potential	The potential a spacecraft comes to under current balance with the surrounding plasma.
Frequency	The number of complete cycles or vibrations per unit of time.

Glow Discharge A nearby luminous neutral plasma of high charge density. A cathode will have a surface glow at low pressure and higher fields, owing to the excitation of the incoming positive ions and neutralization at the surface.

Graded Insulation Combination insulations with the portions thereof arranged in such a manner as to improve the distribution of the electric field to which the insulation combination is subjected.

Gradient Rate of increase or decrease of a variable parameter.

Grounded Parts Parts that are so connected that, when the installation is complete, they are substantially at the same potential as the earth.

Ground Insulation The major insulation used between a winding and the magnetic core or other structural parts, usually at ground potential.

Hardener A substance or mixture of substances added to plastic composition or an adhesive to promote or control curing.

Heat Sink Any device that absorbs and stores energy from a hot object.

Hertz (Hz) A term replacing cycles-per-second as a unit of frequency.

Hollow Cathode An efficient plasma emitting device flowing gas through a hollow orifice.

Hygroscopic Tending to absorb moisture.

Impedance The total opposition that a circuit offers to the flow of alternating current or any other time varying current at a particular frequency. It is a combination of resistance R and reactance X, measured in ohms, and designated by, $Z= (R^2 + X^2)^{1/2}$.

Impregnate To fill the voids and interstices of a material with a compound.

Impulse A unidirectional surge generated by the release of electric energy into an impedance network.

lmpulse Ratio The ratio of the flashover, sparkover, or breakdown voltage of an impulse to the crest value of the power-frequency flashover, sparkover, or breakdown voltage.

Insulation Material having a high resistance to the flow of electric current to prevent leakage of current from a conductor-

Insulation Resistance The ratio of the applied voltage to the total current between two electrodes in contact with a specific insulator.

Insulation System	All of the insulation materials used to insulate a particular electrical or electronic product.
Insulator	A material of such low electrical conductivity that the flow of current through it can usually be neglected.
Ion	An electrified portion of matter of sub-atomic, atomic, or molecular dimensions such as is formed when a molecule of gas loses an electron (when the gas is stressed electrically beyond the critical voltage) or when a neutral atom or group of atoms in a fluid loss or gains one or more electrons.
Ion Exchange Resins	Small granular or bead-like particles containing acidic or basic groups which will trade ions with salts in solutions.
Ionization	Generally the dissociation of an atom or molecule into positive or negative ions or electrons. Restrictively the state of an insulator whereby it facilitates the passage of current due to the presence of charged particles (usually induced artificially).
Laminated Plastics	Layers of a synthetic resin-impregnated or coated base material bonded together by means of heat and pressure to form a single piece.
Lamination	The process of preparing a laminate. Also any layer in a laminate.
Mat	A randomly distributed felt of glass fibers used in reinforced plastics.
Moisture Resistance	The ability of a material to resist absorption from the air or when immersed in water.
Nylon	The generic name for synthetic fiber-forming polyamides.
Organic	Designating or composed of matter originating in plant or animal life or composed of chemicals of hydrocarbon origin either natural or synthetic.
Oscillatory Surge	A surge which includes both positive and negative polarity values.
Over-potential	A voltage above the normal operating voltage of a device or circuit.
Paschen Discharge	Breakdown of neutral gas in a high electric field.

Partial Discharge	A partial discharge is an electric discharge that only partially bridges the insulation system between conductors when the voltage stress exceeds a critical value. These partial discharges may, or may not occur adjacent to a conductor. Partial discharge is often referred to as "corona" but the term "corona" is preferably reserved for localized -discharges in cases around a conductor, bare or insulated, remote from any other solid insulation.
Partial Discharge Pulse	A partial discharge pulse is a voltage or current pulse that occurs at some designated location in the test circuit as a result of a partial discharge.
Partial Discharge Pulse Charge	The quantity of charge supplied to the test specimen's terminals from the applied voltage source after a partial discharge pulse has occurred. The pulse charge is often referred to as the apparent charge or terminal charge. The pulse charge is related but not necessarily equal to the quantity of charge flowing in the localized discharge.
Partial Discharge Pulse Energy	The partial discharge pulse energy is the energy dissipated during one individual partial discharge.
Partial Discharge Pulse Repetition Rate	The partial discharge pulse repetition rate is the number of partial discharge pulses of specified magnitude per unit time.
Partial Discharge Pulse Voltage	The peak value of the voltage pulse which. if inserted in the test circuit at a terminal of the test specimen, would produce a response in the circuit equivalent to that resulting from a partial discharge pulse within the specimen. The pulse voltage is also referred to as the terminal corona pulse voltage.
Particulate (space particulate debris)	The sources of spacecraft particulate debris are, earth, spacecraft, and space environments. Earth particulate is mostly dust, sand, and the rocket exhaust. Sources are materials spalled by cosmic dust impacts on materials and the solar array, outgassing products, and slip rings. Space environment are the residues that form the space plasma, cosmic dust of masses less than one gram, micrometeoroids, and meteoroids.
Permittivity	The dielectric constant multiplied by the permittivity of empty space, where the permittivity of empty space, ε_0, is a constant appearing in Coulomb's Law.
Phenolic Resin	A synthetic resin produced by the condensation of phenol with formaldehyde.

Plasma	A gaseous body of ions and electrons of sufficiently low density that considerable charge separation is possible. Because of the mobility of charge, a plasma is normally neutral and free of electric field in its interior, just like a metallic conductor.
Plastic	High polymeric substances, including both natural and synthetic products, but excluding the rubbers, that are capable of flowing under heat and pressure at one time or another.
Polyamide	A polymer in which the structural units arc linked by amide or thioamide groupings
Polycarbonate Resins	Polymers derived from the direct reaction between aromatic and aliphatic dihydroxy compounds with phosgene or by the ester exchange-reaction with appropriate phosgene derived precursors.
Polyester	A resin formed by the reaction between a dibasic acid and a dihydroxy alcohol.
Polyethylene	A thermoplastic material composed of polymers of ethylene.
Polyisobutylene	The polymerization product of isobutylene, also called butyl rubber.
Polymer	A compound formed by polymerization that results in the chemical union of monomers or the continued reaction between lower molecular weight polymers.
Polymerize	To unite chemically two or more monomers or polymers of the same kind to form a molecule with higher molecular weight.
Polymethyl Methacrylate	A transparent thermoplastic composed of polymers of methyl methacrylate.
Polypropylene	A plastic made by the polymerization of high-purity propylene gas in the presence of an organometallic catalyst at relatively low -pressures and temperatures.
Polystyrene	A thermoplastic produced by the polymerization of styrene (vinyl benzene).
Polyvinyl Acetate	A thermoplastic material composed of polymers of vinyl acetate.
Polyvinyl Butyral	A thermoplastic material derived from butyraldehyde.
Polyvinyl Chloride (PVC)	A thermoplastic material composed of polymers of vinyl chloride.

Polyvinyl Chloride Acetate A thermoplastic material composed of copolymers of vinyl chloride and vinyl acetate.

Polyvinylidene Chloride A thermoplastic material composed of polymers of vinylidene chloride (1.1-dichloroethylene).

Potential The work per unit charge required to bring any charge to the point from an infinite distance.

Potting Similar to encapsulating except that steps are taken to insure complete penetration of all voids in the object before the resin polymerizes.

Power The time rate at which work is done. Power is obtained in watts if work is expressed in joules and time is in seconds.

Pressure Force per unit area. Absolute pressure is measured with respect to zero pressure. Gauge pressure is measured with respect to atmospheric pressure.

Proton An elementary particle that is the positively charged constituent of ordinary matter and, together with the neutron, is a building stone of all atomic nuclei.

Pulse A wave that departs from a first nominal state attains a second nominal state, and ultimately returns to the first nominal state.

Relative Humidity Ratio of the quantity of water vapor present in the air to the quantity that would saturate it at any given temperature.

Resin An organic substance of natural or synthetic origin characterized by being polymeric in structure and predominantly amorphous. Most resins, though not all, are of high molecular weight and consist of long chain or network molecular structure. Usually resins are more soluble in their lower molecular weight forms.

Resistance Property of a conductor that determines the current produced by a given difference of potential. The ohm is the practical unit of resistance.

Resistivity The ability of a material to resist passage of electrical current either through its bulk or on a surface. The unit of volume resistivity is the ohm-cm.

Schering Bridge A four-arm alternating-current bridge used to measure capacitance and dissipation factor; bridge balance is independent of frequency.

Semiconductor	A solid crystalline material whose electrical conductivity is intermediate between that of insulators and conductors, and is usually applied-field and temperature-dependent.
Shelf Life	Length of time under specified conditions that a material retains its usability.
Silicone	Polymeric materials in which the recurring chemical group contains silicon and oxygen atoms as links in the main molecular chain.
Sparkover (spark)	A short-duration electric discharge due to a sudden breakdown of air of some other dielectric material separating two terminals, accompanied by a momentary flash of light. Also known as electric spark; spark discharge; sparkover..
Storage Life	The period of time during which a liquid resin or adhesive can be stored and remain suitable for use. Also called Shelf Life.
Surface Creepage Voltage	See Creepage.
Surface Flashover	See Flashover.
Surface Leakage	The passage of current over the boundary surface of an insulator as distinguished from passage through its volume.
Surface Resistivity	The resistance of a material between two opposite sides of a unit square of its surface. Surface resistivity may vary widely with the conditions of measurement.
Surge	A transient variation in the current and/or potential at a point in the circuit.
Tear Strength	Force required to initiate or continue a tear in a material under specified conditions.
Tensile Strength	Maximum stress a material subjected to a stretching load can withstand without tearing. Also known as hot strength.
Thermal Conductivity	Ability of a material to transport thermal energy.
Thermal Endurance	The time at a selected temperature for an insulating material or system of materials to deteriorate to some predetermined level of electrical, mechanical, or chemical performance under prescribed conditions of test.

Thermoplastic	A plastic that can be readily softened and resoftened by heating without changing its inherent properties.
Tracking	Scintillation of the surface of an insulator. May produce enough heat to leave a degraded track of carbon.
Tracking Resistance	See arc resistance.
Transient	That part of the change in a variable that disappears during transition from one steady state operating condition to another.
Urea-Formaldehyde Resin	A synthetic resin formed by the reaction of urea with formaldehyde. An amino resin.
Urethane	A synthetic resin formed by the reaction of a isocyanate resin (nitrogen, carbon, and oxygen radical) with an alcohol.
Vinyl Resin	A synthetic resin formed by the polymerization of compounds containing the group CH2 a CH-.
Void	A small enclosed cavity within an insulation system. It may be centrally located or be next to an electrode surface.
Voltage	The term most often used in place of electromotive force, potential difference, or voltage drop, to designate electric pressure that exists between two points and is capable of producing a flow of current when a closed circuit is connected between the two points.
Volume Resistivity (Specific Insulation Resistance)	The electrical resistance between opposite faces of a 1-cm cube of an insulating material, commonly expressed in ohm-centimeters. The recommended test is ASTM D257-61.
Wire	A metallic conductor of round, square, or rectangular cross-section, which may be either bare or insulated.
Working Life	The period of time during which a liquid resin or adhesive after mixing with catalyst solvent, or other compounding ingredients, remains usable.

APPENDIX B

CASI BILIOGRAPHY

TITLE: ***Computational procedure used in the development of the MSFC modified Jacchia model atmosphere /1967/***

Document ID: 19700031574 N (70N40890) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI
Authors:
(Author(s) Not Available)
Journal Title: CE ENVIRONMENT CRITERIA GUIDELINES FOR USE IN SPACE VEHICLE DEVELOP. 26 AUG. 1970 (SEE N70-40876 23-30) 23-30/
Published: Aug 26, 1970
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 11
Contract Number: None
NASA Subject Category: GEOPHYSICS
Abstract:
Computational procedure for modified **Jacchia** model atmosphere development
Major Subject Terms:
ATMOSPHERIC MODELS   COMPUTER PROGRAMS
Minor Subject Terms:
AEROSPACE ENVIRONMENTS   ATMOSPHERIC DENSITY   ATMOSPHERIC TEMPERATURE   MEASURE AND INTEGRATION   MOLECULAR WEIGHT   SOLAR POSITION   SPACE PROGRAMS
Language Note: English
Notes:
IN ITS SPACE ENVIRONMENT CRITERIA GUIDELINES FOR USE IN SPACE VEHICLE DEVELOP. 26 AUG. 1970 /SEE N70-40876 23-30/

NASA STI Help Desk
E-mail: help@sti.nasa.gov
Phone: 301-621-0390 FAX: 301-621-0134

TITLE: ***High voltage solar array operation in the ionosphere***

Document ID: **19710035397** A (71A16094) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Kennerud, K. L.
Published: Jan 01, 1970
Publisher: INST. OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.,
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 5
Contract Number: None
NASA Subject Category: AUXILIARY SYSTEMS
Abstract:
High voltage solar cell array operation for satellite in ionosphere, discussing plasma leakage current minimization by electrical insulation
Major Subject Terms:
ELECTRICAL INSULATION IONOSPHERIC CONDUCTIVITY PLASMA CONDUCTIVITY SOLAR CELLS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
CONFERENCES HIGH VOLTAGES ION PROPULSION LEAKAGE SYNCHRONOUS SATELLITES
Language Note: English
Notes:
IN- INST. OF ELECTRICAL AND ELECTRONICS ENGINEERS, PHOTOVOLTAIC SPECIALISTS CONFERENCE, 8TH, SEATTLE, WASH., AUG. 4-6, 1970, CONFERENCE RECORD. P. 282-286. /A71-16053 05-03/
NASA-SUPPORTED RESEARCH.
PHOTOVOLTAIC SPECIALISTS CONFERENCE SEATTLE, WA AUG. 4-6, 1970

TITLE: ***High voltage solar array experiments***

Document ID: **19740009675** N (74N17788) **File Series**: NASA Technical Reports
Report Number: NASA-CR-121280
Sales Agency & Price: CASI Hardcopy A07 CASI Microfiche A02
Authors:
Kennerud, K. L. (Boeing Aerospace Co.)
Published: Mar 01, 1974
Corporate Source:
Boeing Aerospace Co. (Seattle, WA, United States)
Pages: 136
Contract Number: NAS3-14364
NASA Subject Category: AUXILIARY SYSTEMS
Abstract:
The interaction between the components of a high voltage solar array and a simulated space plasma is studied to obtain data for the design of a high voltage solar array capable of 15kW at 2 to 16kV. Testing was conducted in a vacuum chamber 1.5-m long by 1.5-m diameter having a plasma source which simulated the plasma conditions existing in earth orbit between 400 nautical miles and synchronous altitude. Test samples included solar array segments pinholes in insulation covering high voltage electrodes, and plain dielectric samples. Quantitative data are presented in the areas of plasma power losses, plasma and high voltage induced damage, and dielectric properties. Limitations of the investigation are described.
Major Subject Terms:
PLASMA-ELECTROMAGNETIC INTERACTION SOLAR ARRAYS SPACE ENVIRONMENT SIMULATION
Minor Subject Terms:
EARTH ORBITS PLASMA DIAGNOSTICS PLASMA LOSS SOLAR CELLS
Language Note: English

NASA STI Help Desk
E-mail: help@sti.nasa.gov
Phone: 301-621-0390 FAX: 301-621-0134

TITLE: ***The design and development of a space laboratory to conduct magnetospheric and plasma research***

Document ID: **19750035098** A (75A19170) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Rosen, A. (TRW Systems Group)
Published: Jan 01, 1974
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 14
Contract Number: NAS8-28047
NASA Subject Category: LAUNCH VEHICLES AND SPACE VEHICLES
Abstract:
A design study was conducted concerning a proposed shuttle-borne space laboratory for research on magnetospheric and plasma physics. A worldwide survey found two broad research disciplines of interest: geophysical studies of the dynamics and structure of the magnetosphere (including wave characteristics, wave-particle interactions, magnetospheric modifications, beam-plasma interactions, and energetic particles and tracers) and plasma physics studies (plasma physics in space, wake and sheath studies, and propulsion and devices). The Plasma Physics and Environmental Perturbation Laboratory (PPEPL) designed to perform experiments in these areas will include two 50-m booms and two maneuverable subsatellites, a photometer array, standardized proton, electron, and plasma accelerators, a high-powered transmitter for frequencies above 100 kHz, a low-power transmitter for VLF and below, and complete diagnostic packages. Problem areas in the design of a space plasma physics laboratory are indicated.
Major Subject Terms:
EARTH MAGNETOSPHERE PLASMA PHYSICS SPACE LABORATORIES SPACE SHUTTLES SPACECRAFT DESIGN
Minor Subject Terms:
GEOPHYSICS PARTICLE INTERACTIONS RESEARCH FACILITIES SPACE PROGRAMS WAVE INTERACTION
Language Note: English
Notes:
In: Correlated interplanetary and magnetospheric observations; Proceedings of the Seventh ESLAB Symposium, Saulgau, West Germany, May 22-25, 1973. (A75-19126 06-46) Dordrecht, D. Reidel Publishing Co., 1974, p. 649-662.
Correlated interplanetary and magnetospheric observations; Seventh ESLAB Symposium Saulgau May 22-25, 1973

TITLE: ***Large discharges and arcs on spacecraft***

Document ID: **19750048381** A (75A32453) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Rosen, A. (TRW Systems Group)

Journal Title: Astronautics and Aeronautics **Volume**: 13 **Page**: June 197
Published: Jun 01, 1975
Corporate Source:

(Corporate Source(s) Not Available)

Pages: 9
Contract Number: F04701-69-C-0091
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

Observations of satellite performance anomalies are reviewed which have recently been concluded to result from high-voltage differential charging of the satellites during magnetic substorms and subsequent vacuum-arc discharging, with its consequent electromagnetic interference. It is recommended that the spacecraft design field take remedial action, through a program of applied research and testing, to prevent this arcing, which is particularly common at geosynchronous altitudes.

Major Subject Terms:

ARC DISCHARGES CHARGING ELECTRICAL FAULTS ENVIRONMENT EFFECTS MAGNETIC STORMS SPACECRAFT RELIABILITY

Minor Subject Terms:

FAILURE ANALYSIS HIGH VOLTAGES PLASMA INTERACTIONS POLAR SUBSTORMS SOLAR WIND SPACECRAFT SHIELDING SYNCHRONOUS SATELLITES

Language Note: English
Notes:

Astronautics and Aeronautics, vol. 13, June 1975, p. 36-44.
p. 36-44

TITLE: ***Laboratory 15 kV high voltage solar array facility***

Document ID: **19760009534** N (76N16622) **File Series**: NASA Technical Reports
Report Number: NASA-TM-X-71860 E-8619
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Kolecki, J. C. (NASA Lewis Research Center) Gooder, S. T. (NASA Lewis Research Center)
Published: Jan 01, 1976
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 29
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The laboratory high voltage solar array facility is a photoelectric power generating system. Consisting of nine modules with over 23,000 solar cells, the facility is capable of delivering more than a kilowatt of power. The physical and electrical characteristics of the facility are described.
Major Subject Terms:
PHOTOELECTRIC GENERATORS SOLAR ARRAYS TEST FACILITIES
Minor Subject Terms:
ELECTRICAL PROPERTIES ENERGY TECHNOLOGY SOLAR ENERGY CONVERSION
Language Note: English

TITLE: ***U.S. standard atmosphere, 1976***

Document ID: 19770009539 N (77N16482) **File Series**: NASA Technical Reports
Report Number: NASA-TM-X-74335   NOAA-**S**/T-76-1562
Sales Agency & Price: CASI Hardcopy A11   CASI Microfiche A03
Authors:
(Author(s) Not Available)
Published: Oct 01, 1976
Corporate Source:
NASA (Washington, DC, United States)
National Oceanic and Atmospheric Administration (Washington, DC, United States)
Department of the Air Force (Washington, DC, United States)
Pages: 241
Contract Number: None
NASA Subject Category: GEOPHYSICS
Abstract:
Part 1 gives the basis for computation of the main tables of atmospheric properties, including values of physical constants, conversion factors, and definitions of derived properties, including values of physical constants, conversion factors, and definitions of derived properties. Part 2 describes the model and data used up to 85 km, in the first section; and the model and data used above 85 km in the second section. The theoretical basis of the high altitude model is given in an appendix. Part 3 contains information on minor constituents in the troposphere, stratosphere, and mesosphere. The main tables of atmospheric properties to 1000 km are given in Part 4. The international system of metric units is used.
Major Subject Terms:
LOWER **ATMOSPHERE**   METEOROLOGICAL PARAMETERS   STANDARDS   UNITED STATES   UPPER **ATMOSPHERE**
Minor Subject Terms:
ATMOSPHERIC MODELS   RADIOSONDES   ROCKET SOUNDING   STRATOSPHERE   TABLES (DATA)   TROPOSPHERE
Language Note: English
Notes:
Prepared in cooperation with NOAA and the US Air Force

TITLE: ***Spacecraft charging by magnetospheric plasmas; Symposium, Washington, D.C., June 16-19, 1975, Technical Papers***

Document ID: **19770029677** A (77A12529) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Rosen, A. (TRW, Inc.)
Published: Jan 01, 1976
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 302
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Spacecraft charging technology programs are examined and topics related to an environmental interaction with spacecraft are considered. Attention is given to a correlation study relating spacecraft anomalies to environmental data, observations of electrical discharges caused by differential satellite charging, spacecraft potentials in a substorm environment, the simulation of the plasma sheath surrounding a charged spacecraft, spacecraft potential control with electron emitters, and the active control of spacecraft potentials at geosynchronous orbit. Questions related to the response of spacecraft materials to the arcing process are investigated, taking into account the spacecraft material response to geosynchronous substorm conditions, surface discharges on spacecraft dielectrics in a scanning electron microscope, and evidence for a new discharge mechanism for dielectrics in a plasma. Individual items are announced in this issue.
Major Subject Terms:
CONFERENCES • EARTH MAGNETOSPHERE • PLASMA INTERACTIONS • SPACECRAFT CHARGING • SPACECRAFT CONSTRUCTION MATERIALS • SYNCHRONOUS SATELLITES
Minor Subject Terms:
AEROSPACE ENVIRONMENTS • ATS 6 • DIELECTRICS • ELECTRIC DISCHARGES • ELECTRIC POTENTIAL • ELECTRICAL FAULTS • EXTERNAL SURFACE CURRENTS • HIGH ALTITUDE ENVIRONMENTS • MAGNETIC STORMS • RESEARCH PROJECTS • SPECTROMETERS
Language Note: English
Notes:
Symposium sponsored by the American Institute of Aeronautics and Astronautics and American Geophysical Union New York, American Institute of Aeronautics and Astronautics, Inc. (Progress in Astronautics and Aeronautics. Volume 47); Cambridge, Mass., MIT Press, 1976. 302 p.
Symposium on Spacecraft charging by magnetospheric plasmas Washington, DC June 16-19, 1975

TITLE: Spacecraft charging by magnetospheric plasmas
Document ID: **19770035216** A (77A18068) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Rosen, A. (TRW Defense and Space Systems Group)
Published: Dec 01, 1976
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 7
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
A potentially catastrophic environmental phenomenon, large discharges and arcs on spacecraft induced by magnetospheric substorm events, was probably responsible for numerous spacecraft malfunctions and at least one spacecraft failure. Electromagnetic interference resulting from the arc is induced into various spacecraft circuits, triggering integrated circuit switches, multivibrators and one-shots, plus degradation of thermal blankets, contamination of surfaces by vaporization products, triggering of light sensitive devices, and anomalous functioning of scientific sensors. This paper reviews the charging phenomenon, its hazards and the response of the scientific and engineering community during the past few years. The general program includes (1) standard environmental specification to cover the geomagnetic substorm environment; (2) general design requirements and criteria-guidelines for design of spacecraft to be resistant to the effects of geomagnetic substorms; (3) analytic tools to determine and predict stress levels induced by the substorm charging environment; (4) test programs to verify the immunity of spacecraft to environmental substorm charging and arcing; and (5) housekeeping data, environmental data, and laboratory test data.
Major Subject Terms:
CIRCUIT RELIABILITY • EARTH MAGNETOSPHERE • ELECTROMAGNETIC INTERFERENCE • MAGNETIC STORMS • PLASMA INTERACTIONS • SPACECRAFT CHARGING • SPACECRAFT RELIABILITY
Minor Subject Terms:
ELECTRIC ARCS • INTEGRATED CIRCUITS • PLASMA SHEATHS • SPACECRAFT ELECTRONIC EQUIPMENT • SPACECRAFT ENVIRONMENTS • TRIGGER CIRCUITS
Language Note: English
Notes:
(Institute of Electrical and Electronics Engineers, Annual Conference on Nuclear and Space Radiation Effects, 13th, La Jolla, Calif., July 27-30, 1976.) IEEE Transactions on Nuclear Science, vol. NS-23, Dec. 1976, p. 1762-1768.

TITLE: ***Static and dynamic behavior of spherical probe and satellite plasma sheaths***

Document ID: **19770035223** A (77A18075) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Katz, I. Wilson, A. (Systems, Science and Software, La Jolla) Parker, L. W. (Lee W. Parker, Inc.) Rothwell, P. L. Rubin, A. G. (USAF, Geophysics Laboratory, Bedford)
Published: Dec 01, 1976
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The time dependence of the interactions between spacecraft plasmas is considered. Specially designed particle simulation codes are used in a study concerning the dynamical interaction of an idealized satellite with several different plasmas. The numerical techniques utilized in the dynamical codes are examined, questions of noise and accuracy are briefly explored, and the results of several sets of computations are presented. In each case, the system is found to relax to a steady state, the very same steady state predicted from equilibrium theory.
Major Subject Terms:
DYNAMIC CHARACTERISTICS ELECTROSTATIC PROBES PLASMA SHEATHS PLASMA-PARTICLE INTERACTIONS SATELLITE CONFIGURATIONS TIME DEPENDENCE
Minor Subject Terms:
DEBYE LENGTH DIGITAL TECHNIQUES ELECTRIC POTENTIAL PHOTOELECTRIC EMISSION PLASMA DECAY PLASMA OSCILLATIONS SPACE CHARGE SPHERES
Language Note: English
Notes:
(Institute of Electrical and Electronics Engineers, Annual Conference on Nuclear and Space Radiation Effects, 13th, La Jolla, Calif., July 27-30, 1976.) IEEE Transactions on Nuclear Science, vol. NS-23, Dec. 1976, p. 1814-1819. Research supported by the U.S. Defense Nuclear Agency and U.S. Air Force.

TITLE: ***Charging characteristics of materials: Comparison of experimental results with simple analytical models***

Document ID: **19780002214** N (78N10157) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E06
Authors:

Purvis, C. K. (NASA Lewis Research Center) Stevens, N. J. (NASA Lewis Research Center) Oglebay, J. C. (NASA Lewis Research Center)

Journal Title: Proc. of the Spacecraft Charging Technol. Conf. **Page**: p 459-486
Published: Feb 24, 1977
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 28
Contract Number: None
NASA Subject Category: METALLIC MATERIALS
Abstract:

A one-dimensional model for charging of samples is used in conjunction with experimental data taken to develop material charging characteristics for silvered Teflon. These characteristics are then used in a one dimensional model for charging in space to examine expected response. Relative charging rates as well as relative charging levels for silvered Teflon and metal are discussed.

Major Subject Terms:

ASTRONOMICAL MODELS ELECTROSTATIC CHARGE MATERIALS TESTS SPACECRAFT CHARGING

Minor Subject Terms:

CHARGED PARTICLES CHARGING DIELECTRICS EXPERIMENTATION MECHANICAL PROPERTIES PARTICLE COLLISIONS TEFLON (TRADEMARK)

Language Note: English
Notes:

In its Proc. of the Spacecraft Charging Technol. Conf. p 459-486 (SEE N78-10129 01-12)

TITLE: ***Interaction of large, high power systems with operational orbit charged particle environments***

Document ID: **19780008133** N (78N16076) **File Series**: NASA Technical Reports
Report Number: NASA-TM-73867 E-9459
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Purvis, C. K. (NASA Lewis Research Center) Stevens, N. J. (NASA Lewis Research Center) Berkopec, F. D. (NASA Lewis Research Center)
Published: Jan 01, 1977
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 19
Contract Number: None
NASA Subject Category: ASTRONAUTICS (GENERAL)
Abstract:
A potentially hazardous spacecraft environment interaction is discussed. The interaction of large high voltage systems with low energy (less than 50 eV) plasmas which can result in loss of power and/or arching was examined. The impact of this class of interactions where the ambient operation is most severe at low orbits where the ambient plasmas are densest. Results of experimental work and predictions of simple analytical models were presented and their implications for design of space systems were reviewed.
Major Subject Terms:
CHARGED PARTICLES EARTH ORBITS HIGH VOLTAGES PARTICLE INTERACTIONS SPACECRAFT ENVIRONMENTS
Minor Subject Terms:
AEROSPACE ENGINEERING GEOSYNCHRONOUS ORBITS PLASMA POWER SOURCES SOLAR ARRAYS THERMAL ENVIRONMENTS
Language Note: English
Notes:
Presented at the Meeting on Long Range Planning for the Ind. Phase of Space Exploration, San Francisco, 18-20 Oct. 1977; Sponsored by the Am. Astronautical Soc.
Meeting on Long Range Planning for the Ind. Phase of Space Exploration San Francisco 18-20 Oct. 1977

TITLE: ***Status of the NASA-Lewis Research Center spacecraft charging investigation***

Document ID: **19780019227** N (78N27170) **File Series**: NASA Technical Reports
Report Number: NASA-TM-78938 E-9682
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Stevens, N. J. (NASA Lewis Research Center) Berkopec, F. D. (NASA Lewis Research Center) Purvis, C. K. (NASA Lewis Research Center)
Published: Jan 01, 1978
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 25
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The technology necessary to control the absolute and differental charging of spacecraft surfaces is detailed for developing ground simulation facilities, characterizing the charging and discharging characteristics of spacecraft materials, deriving analytical modelling tools and issuing design guideline documents. Facilities were developed and testing of various materials was completed. Comparisons between experimental results, space results and predictions from models were made. Harness transient monitors were flown on satellites.
Major Subject Terms:
MATERIALS TESTS SPACECRAFT CHARGING SPACECRAFT CONSTRUCTION MATERIALS TECHNOLOGY ASSESSMENT TEST FACILITIES
Minor Subject Terms:
MAGNETOSTATICS SPACE ENVIRONMENT SIMULATION STATIC ELECTRICITY
Language Note: English
Notes:
Presented at the Spacecraft Electromagnetic Compatibility Seminar, Noordwijk, The Netherlands, 24-26 May 1978; sponsored by the European Space Research and Technology Centre (ESTEC)
Spacecraft Electromagnetic Compatibility Seminar Noordwijk 24-26 May 1978

TITLE: ***A computer version of the US Standard Atmosphere, 1978***

Document ID: 19780023689 N (78N31632) **File Series**: NASA Technical Reports
Report Number: NASA-CR-150778
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
King, R. L. (Science Applications, Inc.)
Published: Aug 01, 1978
Corporate Source:
Science Applications, Inc. (Huntsville, AL, United States)
Pages: 49
Contract Number: NAS8-32226
NASA Subject Category: GEOPHYSICS
Abstract:
A computer version of the **U**.**S**. **Standard Atmosphere**, 1976, was developed. The computer program was developed in modular form for easy incorporation into the user**'s** program and for easy modification for specialized uses.
Major Subject Terms:
COMPUTER PROGRAMS REFERENCE ATMOSPHERES UNITED STATES
Minor Subject Terms:
EFFICIENCY MODULES STANDARDS
Language Note: English

TITLE: ***Investigation of high voltage spacecraft system interactions with plasma environments***

Document ID: **19780048841** A (78A32750) **File Series**: Open Literature
Report Number: AIAA PAPER 78-672
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Stevens, N. J. (NASA Lewis Research Center) Berkopec, F. D. (NASA Lewis Research Center) Purvis, C. K. (NASA Lewis Research Center) Grier, N. (NASA Lewis Research Center) Staskus, J. (NASA Lewis Research Center)
Published: Apr 01, 1978
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 14
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The exposure of high voltage spacecraft systems to the charged particle environment of space can produce interactions that will influence system operation. An experimental investigation of these interactions has been undertaken for insulator and conductor test surfaces biased up to plus or minus 1 kV in a simulated low earth orbit charged particle environment. It has been found that these interactions are controlled by the insulator surfaces surrounding the biased conductors. For positive applied voltages the electron current collection can be enhanced by the insulators. For negative applied voltages the insulator surface confines the voltage to the conductor region; this can cause arcing. Understanding these interactions and the technology to control their impact on system operation is essential to the design of solar cell arrays for ion drive propulsion applications that use direct drive power processing.
Major Subject Terms:
PLASMA CONDUCTIVITY PLASMA INTERACTIONS SPACECRAFT ENVIRONMENTS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
ELECTRIC ARCS ELECTRICAL INSULATION GROUND TESTS HIGH VOLTAGES KAPTON (TRADEMARK) LOW EARTH ORBITS SOLAR ARRAYS SOLAR ELECTRIC PROPULSION SPACECRAFT CHARGING
Language Note: English
Notes:
American Institute of Aeronautics and Astronautics and Deutsche Gesellschaft fuer Luft- und Raumfahrt, International Electric Propulsion Conference, 13th, San Diego, Calif., Apr. 25-27, 1978, AIAA 14 p.
International Electric Propulsion Conference San Diego, CA Apr. 25-27, 1978

TITLE: ***Interaction of large, high power systems with operational orbit charged particle environments***

Document ID: **19780052810** A (78A36719) **File Series**: Open Literature
Report Number: AAS 77-243
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Purvis, C. K. (NASA Lewis Research Center) Stevens, N. J. (NASA Lewis Research Center) Berkopec, F. D. (NASA Lewis Research Center)
Published: Jan 01, 1978
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 18
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Concepts are presently being advanced for space systems to be used for such activities as manufacturing, earth observations, scientific exploration, power generation and human habitation, in locations ranging from low earth orbit (300-500 km) to geosynchronous orbit and beyond. Many of these systems concepts envision large structures and high power levels, and consequently higher operating voltages than have been used in space to date. The potential impact of interactions of space systems with their operational orbit charged particle environments on the systems' performance must be accounted for in the design process. A potentially hazardous spacecraft-environment interaction is discussed, namely the interaction of large high voltage systems with low energy (less than 50 eV) plasmas which can result in loss of power, and/or arcing. The impact of this class of interactions on system operation is most severe at low orbits where the ambient plasmas are densest. Results of experimental work and predictions of simple analytical models are presented and their implications for design of space systems are discussed.
Major Subject Terms:
ELECTRIC ARCS LARGE SPACE STRUCTURES SOLAR ARRAYS SPACECRAFT CHARGING SPACECRAFT ORBITS
Minor Subject Terms:
CHARGED PARTICLES HIGH VOLTAGES LOW EARTH ORBITS PLASMAS (PHYSICS) SOLAR CELLS SPACE COMMERCIALIZATION SPACECRAFT POWER SUPPLIES
Language Note: English
Notes:
In: The industrialization of space; Proceedings of the Twenty-third Annual Meeting, San Francisco, Calif., October 18-20, 1977. Part 1. (A78-36701 15-12) San Diego, Calif., American Astronautical Society; Univelt, Inc., 1978, p. 429-446.
Annual Meeting San Francisco, CA October 18-20, 1977

TITLE: ***Insulator edge voltage gradient effects in spacecraft charging phenomena***

Document ID: **19790002938** N (79N11109) **File Series**: NASA Technical Reports
Report Number: NASA-TM-78988 E-9769
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Stevens, N. J. (NASA Lewis Research Center) Purvis, C. K. (NASA Lewis Research Center) Staskus, J. V. (NASA Lewis Research Center)
Published: Jan 01, 1978
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 16
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Insulating surfaces on geosynchronous satellites were charged by geomagnetic substorms to a point where discharges occur. The electromagnetic pulses from these discharges couple into satellite electronic systems disrupting operations are examined. Laboratory tests conducted on insulator charging have indicated that discharges appear to be initiated at insulator edges where voltage gradients can exist. An experimental investigation was conducted to measure edge voltage gradients on silvered Teflon samples as they are charged by monoenergetic electron beams. It was found that the surface voltage at insulator edges can be approximated by an exponential expression based on an electron current density balance.
Major Subject Terms:
ELECTRIC POTENTIAL GRADIENTS INSULATORS SPACECRAFT CHARGING
Minor Subject Terms:
EDGES ELECTRIC DISCHARGES ELECTROSTATIC CHARGE GEOSYNCHRONOUS ORBITS MATERIALS HANDLING
Language Note: English
Notes:
Presented at the Ann. Conf. on Nucl. and Space Radiation Effects, Albuquerque, N. Mex., 18-21 Jul. 1978, sponsored by IEEE
Ann. Conf. on Nucl. and Space Radiation Effects Albuquerque, NM 18-21 Jul. 1978

TITLE: ***Effect of parasitic plasma currents on solar-array power output***

Document ID: **19790015854** N (79N24025) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E06
Authors:
Domitz, S. (NASA Lewis Research Center) Kolecki, J. C. (NASA Lewis Research Center)
Journal Title: Spacecraft Charging Technol., 1978 **Page**: p 358-375
Published: Jan 01, 1979
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 18
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Solar-array voltage-current curves are calculated by assuming the existence of parasitic loads that consist of local currents of charged particles collected by the array. Three cases of interest are calculated to demonstrate how the distribution and magnitude of parasitic currents affect output. Solar array performance degradation became significant when the total parasitic current plus the load current exceeded the short-circuit current. Approximate graphical methods were useful for many applications. Power loss, which was calculated by summing the product of parasitic current and the local potential, underestimated the loss in maximum power.
Major Subject Terms:
CHARGED PARTICLES ELECTRIC CURRENT PLASMA INTERACTIONS POWER CONDITIONING SOLAR ARRAYS
Minor Subject Terms:
ANALYSIS (MATHEMATICS) ELECTRIC POTENTIAL GRAPHS (CHARTS) OUTPUT TRANSMISSION LOSS
Language Note: English
Notes:
In its Spacecraft Charging Technol., 1978 p 358-375 (SEE N79-24001 15-18)

TITLE: ***Space environmental effects and the solar power satellite***

Document ID: **19790015857** N (79N24028) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E06
Authors:
Freeman, J. W. (Rice Univ.) Cooke, D. (Rice Univ.) Reiff, P. (Rice Univ.)
Journal Title: NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 **Page**: p 408-418
Published: Jan 01, 1979
Corporate Source:
Rice Univ. (Houston, TX, United States)
Pages: 11
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Some preliminary findings regarding the interactions between the space plasma at GEO and the Marshall Space Flight Center January 1978 baseline Satellite Power Systems (SPS) design are summarized. These include the following: (1) the parasitic load will be dominated by photoelectrons and will amount to about 34 MW; (2) material of higher conductivity than kapton should be used for the solar reflector substrate and the solar cell blanket support material; (3) the satellite structure and solar reflector should be tied electrically to midpoint voltage of each solar cell array; and (4) tests should be run on the proposed solar cell cover glass material (synthetic sapphire) to determine if breakdown is expected.
Major Subject Terms:
AEROSPACE ENVIRONMENTS PLASMA INTERACTIONS SATELLITE SOLAR POWER STATIONS SOLAR ARRAYS SPACECRAFT CHARGING
Minor Subject Terms:
ELECTRIC CURRENT ELECTRIC POTENTIAL GEOSYNCHRONOUS ORBITS KAPTON (TRADEMARK) SOLAR CELLS SOLAR REFLECTORS STRUCTURAL DESIGN CRITERIA
Language Note: English
Notes:
In NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 p 408-418 (SEE N79-24001 15-18)

TITLE: ***Effects of arcing due to spacecraft charging on spacecraft survival***

Document ID: **19790017141** N (79N25312) **File Series**: NASA Technical Reports
Report Number: NASA-CR-159593 TRW-33631-6006-RU-00
Sales Agency & Price: CASI Hardcopy A08 CASI Microfiche A02
Authors:

Rosen, A. (TRW Defense and Space Systems Group) Sanders, N. L. (TRW Defense and Space Systems Group) Ellen, J. M., Jr. (TRW Defense and Space Systems Group) Inouye, G. T. (TRW Defense and Space Systems Group)

Published: Nov 14, 1978
Corporate Source:

TRW Defense and Space Systems Group (Redondo Beach, CA, United States)

Pages: 172
Contract Number: NAS3-21363
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:

A quantitative assessment of the hazard associated with spacecraft charging and arcing on spacecraft systems is presented. A literature survey on arc discharge thresholds and characteristics was done and gaps in the data and requirements for additional experiments were identified. Calculations of coupling of arc discharges into typical spacecraft systems were made and the susceptibility of typical spacecraft to disruption by arc discharges was investigated. Design guidelines and recommended practices to reduce or eliminate the threat of malfunction and failures due to spacecraft charging/arcing were summarized.

Major Subject Terms:

ARC DISCHARGES SAFETY MANAGEMENT SPACECRAFT CHARGING

Minor Subject Terms:

COUPLING ELECTROSTATIC CHARGE HAZARDS

Language Note: English

TITLE: ***Charge-exchange plasma environment for an ion drive spacecraft***

Document ID: **19790025080** N (79N33251) **File Series**: NASA Technical Reports
Report Number: NASA-CR-162358 • JPL-PUB-79-90
Sales Agency & Price: CASI Hardcopy A03 • CASI Microfiche A01
Authors:
Kaufman, H. R. (Colorado State Univ.) • Carruth, M. R., Jr. (Jet Propulsion Lab., California Inst. of Tech.)
Published: Oct 01, 1979
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 37
Contract Number: NAS7-100
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The charge exchange plasma environment around a spacecraft that uses mercury ion thrusters for propulsion is described. The interactions between the plasma environment and the spacecraft are determined and a model which describes the propagation of the mercury charge exchange plasma is discussed. The model is extended to describe the flow of the molybdenum component of the charge exchange plasma. The uncertainties in the models for various conditions are discussed and current drain to the solar array, charge exchange plasma material deposition, and the effects of space plasma on the charge exchange plasma propagation are addressed.
Major Subject Terms:
CHARGE EXCHANGE • ION PROPULSION • MATHEMATICAL MODELS • MERCURY ION ENGINES • PLASMA INTERACTIONS • PLASMAS (PHYSICS) • ROCKET THRUST
Minor Subject Terms:
ELECTRON DENSITY PROFILES • GROUND TESTS • ION EMISSION • MOLYBDENUM • PREDICTION ANALYSIS TECHNIQUES • SOLAR ARRAYS
Language Note: English

TITLE: ***Insulator edge voltage gradient effects in spacecraft charging phenomena***

Document ID: **19790046126** A (79A30139) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:

Stevens, N. J. (NASA Lewis Research Center) Purvis, C. K. (NASA Lewis Research Center) Staskus, J. V. (NASA Lewis Research Center)

Published: Dec 01, 1978
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 9
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

Insulating surfaces on geosynchronous satellites have been charged by geomagnetic substorms to a point where discharges occur. The electromagnetic pulses from these discharges couple into satellite electronic systems disrupting operations. Laboratory tests conducted on insulator charging have indicated that discharges appear to be initiated at insulator edges where voltage gradients can exist. An experimental investigation has been conducted to measure edge voltage gradients on silvered Teflon samples as they are charged by monoenergetic electron beams. It has been found that the surface voltage at insulator edges can be approximated by an exponential expression based on an electron current density balance. Using this expression at known breakdown conditions results in a discharge voltage gradient down the insulator edge to ground of about 150,000 V/cm.

Major Subject Terms:

EDGES ELECTRIC DISCHARGES ELECTRICAL INSULATION POTENTIAL GRADIENTS SPACECRAFT CHARGING SYNCHRONOUS SATELLITES

Minor Subject Terms:

CIRCUIT PROTECTION ELECTRON BEAMS ELECTRON ENERGY GAS IONIZATION HIGH VOLTAGES TEFLON (TRADEMARK)

Language Note: English
Notes:

(IEEE, DNA, NASA, and DOE, Annual Conference on Nuclear and Space Radiation Effects, 15th, Albuquerque, N. Mex., July 18-21, 1978.) IEEE Transactions on Nuclear Science, vol. NS-25, Dec. 1978, p. 1304-1312.

TITLE: ***AFSIM, an Air Force sattellite interactions model***

Document ID: **19800011817** N (80N20300) **File Series**: NASA Technical Reports
Report Number: AD-A078032 AFGL-TR-79-0138 ERP-664
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Mazzella, A. (RDP, Inc.) Tobenfeld, E. (RDP, Inc.) Rubin, A. G. (RDP, Inc.)
Published: Jun 29, 1979
Corporate Source:
RDP, Inc. (Waltham, MA, United States)
Pages: 16
Contract Number: None
NASA Subject Category: LAUNCH VEHICLES AND SPACE VEHICLES
Abstract:
A computer program called AFSIM has been developed to conduct numerical simulations of plasma interactions with a satellite, assuming the satellite to be represented by an infinitely long cylinder and treating the plasma as discrete particles. The system is assumed to be uniform along the axis of the satellite. A number of features of the actual satellite are incorporated into the model with as much flexibility as possible to accommodate a wide range of conditions.
Major Subject Terms:
COMPUTER PROGRAMS PLASMAS (PHYSICS) SCATHA SATELLITE SPACE CHARGE SPACECRAFT CHARGING
Minor Subject Terms:
COMPUTERIZED SIMULATION CYLINDRICAL BODIES SECONDARY EMISSION SURFACE ENERGY
Language Note: English

TITLE: ***Electrostatic protection of the Solar Power Satellite and rectenna***

Document ID: **19800014859** N (80N23348) **File Series**: NASA Technical Reports
Report Number: NASA-CR-161438
Sales Agency & Price: CASI Hardcopy A08 CASI Microfiche A02
Authors:
Freeman, J. W. (Rice Univ.) Few, A. A., Jr. (Rice Univ.) Reiff, P. H. (Rice Univ.) Cooke, D. (Rice Univ.) Bohannon, J. (Rice Univ.) Haymes, B. (Rice Univ.)
Published: May 01, 1979
Corporate Source:
Rice Univ. (Houston, TX, United States)
Pages: 157
Contract Number: NAS8-33023
NASA Subject Category: LAUNCH VEHICLES AND SPACE VEHICLES
Abstract:
Several features of the interactions of the solar power satellite (SPS) with its space environment were examined theoretically. The voltages produced at various surfaces due to space plasmas and the plasma leakage currents through the kapton and sapphire solar cell blankets were calculated. At geosynchronous orbit, this parasitic power loss is only 0.7%, and is easily compensated by oversizing. At low-Earth orbit, the power loss is potentially much larger (3%), and anomalous arcing is expected for the EOTV high voltage negative surfaces. Preliminary results of a three dimensional self-consistent plasma and electric field computer program are presented, confirming the validity of the predictions made from the one dimensional models. Magnetic shielding of the satellite, to reduce the power drain and to protect the solar cells from energetic electron and plasma ion bombardment is considered. It is concluded that minor modifications can allow the SPS to operate safely and efficiently in its space environment. The SPS design employed in this study is the 1978 MSFC baseline design utilizing GaAs solar cells at CR-2 and an aluminum structure.
Major Subject Terms:
AEROSPACE ENVIRONMENTS ELECTROSTATIC SHIELDING RECTENNAS SOLAR POWER SATELLITES SPACECRAFT CHARGING
Minor Subject Terms:
COMPUTERIZED SIMULATION ELECTRIC FIELDS ELECTRIC POTENTIAL LOW EARTH ORBITS MAGNETIC SHIELDING SOLAR CELLS
Language Note: English

TITLE: ***A computer model of solar panel-plasma interactions***

Document ID: **19800024345** N (80N32853) **File Series**: NASA Technical Reports
Report Number: NASA-CR-160796
Sales Agency & Price: CASI Hardcopy A04 CASI Microfiche A01
Authors:
Cooke, D. L. (Rice Univ.) Freeman, J. W. (Rice Univ.)
Published: Jan 01, 1980
Corporate Source:
Rice Univ. (Houston, TX, United States)
Pages: 59
Contract Number: NAS9-15796
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
High power solar arrays for satellite power systems are presently being planned with dimensions of kilometers, and with tens of kilovolts distributed over their surface. Such systems face many plasma interaction problems, such as power leakage to the plasma, particle focusing, and anomalous arcing. These effects cannot be adequately modeled without detailed knowledge of the plasma sheath structure and space charge effects. Laboratory studies of 1 by 10 meter solar array in a simulated low Earth orbit plasma are discussed. The plasma screening process is discussed, program theory is outlined, and a series of calibration models is presented. These models are designed to demonstrate that PANEL is capable of accurate self consistant space charge calculations. Such models include PANEL predictions for the Child-Langmuir diode problem.
Major Subject Terms:
COMPUTER PROGRAMS PLASMA SHEATHS PLASMA-PARTICLE INTERACTIONS SOLAR ARRAYS SOLAR POWER SATELLITES SPACE PLASMAS THERMIONIC DIODES
Minor Subject Terms:
CHILD-LANGMUIR LAW LOW EARTH ORBITS PLASMA PHYSICS POISSON EQUATION SATELLITE POWER TRANSMISSION VLASOV EQUATIONS
Language Note: English

TITLE: ***Active control of spacecraft charging***

Document ID: **19800062720** A (80A46890) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Purvis, C. K. (NASA Lewis Research Center) Bartlett, R. O. (NASA Goddard Space Flight Center)
Published: Jan 01, 1980
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
NASA Goddard Space Flight Center (Greenbelt, MD, United States)
Pages: 19
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The concept of active control of spacecraft charging by charged particle emission is described. Active potential control experiments using the ATS-5 and ATS-6 geostationary spacecraft are discussed, and results of these experiments are presented. Previously reported results are summarized, and a guide to reports on these data are provided. Experimental evidence presented indicates that emission of electrons only is not effective in maintaining spacecraft potential near plasma potential for spacecraft with electrically insulating surfaces. Emission of a low energy plasma, however, is effective for this purpose.
Major Subject Terms:
ATS 5 ATS 6 ELECTRON EMISSION PLASMA POTENTIALS SPACECRAFT CHARGING
Minor Subject Terms:
CHARGED PARTICLES ELECTRICAL INSULATION PHOTOELECTRONS PLASMA CONTROL SATELLITE DESIGN SURFACE REACTIONS
Language Note: English
Notes:
In: Space systems and their interactions with earth's space environment. (A80-46879 20-18) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 299-317.

TITLE: ***Environmental protection of the solar power satellite***

Document ID: **19800062729** A (80A46899) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Reiff, P. H. (Rice Univ.) Freeman, J. W. (Rice University) Cooke, D. L. (Rice Univ.)

Published: Jan 01, 1980
Corporate Source:

Rice Univ. (Houston, TX, United States)

Pages: 23
Contract Number: NAS8-33023
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

This paper examines theoretically several features of the interactions of the Solar Power Satellite (SPS) with its space environment. The leakage currents through the kapton and sapphire solar cell blankets are calculated. At geosynchronous orbit, this parasitic power loss is only 0.7%, and is easily compensated by oversizing. At low-earth orbit, the power loss is potentially much larger (3%), and anomalous arcing is expected for the high-voltage negative surfaces. Preliminary results of a three-dimensional self-consistent plasma and electric field computer program are presented, confirming the validity of the predictions made from the one-dimensional models. Lastly, the paper proposes magnetic shielding of the satellite, to reduce the power drain and to protect the solar cells from energetic electron and plasma ion bombardment. It is concluded that minor modifications from the baseline SPS design can allow the SPS to operate safely and efficiently in its space environment.

Major Subject Terms:

MAGNETIC SHIELDING SATELLITE DESIGN SOLAR CELLS SOLAR POWER SATELLITES SPACECRAFT CHARGING

Minor Subject Terms:

ELECTRIC POTENTIAL ION IMPACT KAPTON (TRADEMARK) LOW EARTH ORBITS PLASMA INTERACTIONS SATELLITE SOLAR POWER STATIONS SELF CONSISTENT FIELDS

Language Note: English
Notes:

In: Space systems and their interactions with earth's space environment. (A80-46879 20-18) New York, American Institute of Aeronautics and Astronautics, Inc., 1980, p. 554-576. Research supported by the Brown Foundation;

TITLE: ***Experimental and analytical evaluation of ion thruster/spacecraft interactions***

Document ID: **19810008609** N (81N17129) **File Series**: NASA Technical Reports
Report Number: NASA-CR-163975 JPL-PUB-80-92
Sales Agency & Price: CASI Hardcopy A11 CASI Microfiche A03
Authors:

Carruth, M. R., Jr. (Jet Propulsion Lab., California Inst. of Tech.)

Published: Jan 15, 1981
Corporate Source:

Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)

Pages: 233
Contract Number: NAS7-100
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

Studies were conducted to both identify the environment produced by ion thrusters and to assess the interaction of this environment on a typical spacecraft and typical science instruments. Spacecraft charging and the charge exchange that accompanies it is discussed in detail. Electromagnetic interference was characterized for ion engines. The electromagnetic compatibility of ion thrusters with spacecraft instruments was determined. The effects of ion thruster plumes on spacecraft were studied with particular emphasis on external surface currents.

Major Subject Terms:

ELECTROMAGNETIC INTERFERENCE EXTERNAL SURFACE CURRENTS ION ENGINES ION PROPULSION SPACECRAFT CHARGING SYSTEM GENERATED ELECTROMAGNETIC PULSES

Minor Subject Terms:

BIAS CHARGE EXCHANGE COLLISIONAL PLASMAS ELECTRIC FIELDS ELECTRIC POTENTIAL ELECTROMAGNETIC COMPATIBILITY ELECTROSTATIC ENGINES MAGNETIC FIELDS PLASMA DENSITY ROCKET EXHAUST SPACE PLASMAS SPACECRAFT INSTRUMENTS

Language Note: English

TITLE: ***Charge-exchange plasma environment for an ion drive spacecraft***

Document ID: **19810008611** N (81N17131) **File Series**: NASA Technical Reports
Report Number: JPL-PUB-79-90
Sales Agency & Price: CASI A02
Authors:
Kaufman, H. R. (Colorado State Univ.) Carruth, M. R., Jr. (Jet Propulsion Lab., California Inst. of Tech.)
Journal Title: Exptl. and Anal. Evaluation of Ion Thruster(Spacecraft Interactions **Page**: p 29-66
Published: Jan 15, 1981
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 36
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
A model was reviewed which describes the propagation of the mercury charge-exchange plasma and extended to describe the flow of the molybdenum component of the charge-exchange plasma. The uncertainties in the models for various conditions are discussed. Such topics as current drain to the solar array, charge-exchange plasma material deposition, and the effects of space plasma on the charge-exchange plasma propagation are addressed.
Major Subject Terms:
CHARGE EXCHANGE ELECTRIC POTENTIAL EXTERNAL SURFACE CURRENTS ION ENGINES MATHEMATICAL MODELS PLASMA PROPULSION SPACE PLASMAS SPACECRAFT CHARGING
Minor Subject Terms:
ELECTRIC FIELDS ELECTROSTATIC ENGINES ION PROPULSION MOLYBDENUM SOLAR ARRAYS SYSTEM GENERATED ELECTROMAGNETIC PULSES
Language Note: English
Notes:
In its Exptl. and Anal. Evaluation of Ion Thruster/Spacecraft Interactions p 29-66 (SEE N81-17129 08-20)

TITLE: ***Propagation of charge-exchange plasma produced by an ion thruster***

Document ID: **19810008612** N (81N17132) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI A02
Authors:
Carruth, M. R., Jr. (Jet Propulsion Lab., California Inst. of Tech.) Brady, M. E. (Boeing Aerospace Co.)
Journal Title: Exptl. and Anal. Evaluation of Ion Thruster(Spacecraft Interactions **Page**: p 67-72
Published: Jan 15, 1981
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Under the proper conditions there is an end-effect of a long, cylindrical Langmuir probe which allows a significant increase in collected ion current when the probe is aligned with a flowing plasma. This effect was used to determine the charge-exchange plasma flow direction at various locations relative to the ion thruster. The ion current collected by the probe as a function of its angle with respect to the plasma flow allows determination of the plasma density and plasma flow velocity at the probe's location upstream of the ion thruster optics. The density values obtained from the ion current agreed to within a factor of two of density values obtained by typical voltage-current Langmuir probe characteristics.
Major Subject Terms:
CHARGE EXCHANGE ELECTRIC FIELDS EXTERNAL SURFACE CURRENTS ION ENGINES ION PROPULSION SPACE PLASMAS SPACECRAFT CHARGING
Minor Subject Terms:
ELECTRIC POTENTIAL ELECTROSTATIC ENGINES ELECTROSTATIC PROBES PLASMA PROPULSION SYSTEM GENERATED ELECTROMAGNETIC PULSES
Language Note: English
Notes:
In its Exptl. and Anal. Evaluation of Ion Thruster/Spacecraft Interactions p 67-72 (SEE N81-17129 08-20)

TITLE: ***Additional application of the NASCAP code. Volume 1: NASCAP extension***

Document ID: **19810019598** N (81N28136) **File Series**: NASA Technical Reports
Report Number: NASA-CR-165349 SSS-R-81-4847-VOL-1
Sales Agency & Price: CASI Hardcopy A07 CASI Microfiche A02
Authors:
Katz, I. (Systems Science and Software) Cassidy, J. J. (Systems Science and Software) Mandell, M. J. (Systems Science and Software) Parks, D. E. (Systems Science and Software) Schnuelle, G. W. (Systems Science and Software) Stannard, P. R. (Systems Science and Software) Steen, P. G. (Systems Science and Software)
Published: Feb 01, 1981
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 126
Contract Number: NAS3-21762
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The NASCAP computer program comprehensively analyzes problems of spacecraft charging. Using a fully three dimensional approach, it can accurately predict spacecraft potentials under a variety of conditions. Several changes were made to NASCAP, and a new code, NASCAP/LEO, was developed. In addition, detailed studies of several spacecraft-environmental interactions and of the SCATHA spacecraft were performed. The NASCAP/LEO program handles situations of relatively short Debye length encountered by large space structures or by any satellite in low earth orbit (LEO).
Major Subject Terms:
COMPUTERIZED SIMULATION PLASMA SHEATHS SPACECRAFT CHARGING
Minor Subject Terms:
BLACKOUT (PROPAGATION) COMPUTER PROGRAMS LOW EARTH ORBITS REENTRY COMMUNICATION
Language Note: English

TITLE: ***The angular impact distribution of charged particles attracted to a charged cylindrical spacecraft***

Document ID: **19820003235** N (82N11108) **File Series**: NASA Technical Reports
Report Number: AD-A104519 AFGL-TR-81-0142 AFGL-ERP-741
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Besse, A. L. (Air Force Geophysics Lab.) Rubin, A. G. (Air Force Geophysics Lab.)
Published: May 13, 1981
Corporate Source:
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 12
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The angular distribution of incident particles is obtained for attracted and repelled particles incident on a charged cylindrical spacecraft. The angular distributions are important when backscattering and secondary emission are significant processes. Results are given for planes and spheres as well.
Major Subject Terms:
ANGULAR DISTRIBUTION CHARGED PARTICLES PARTICLE FLUX DENSITY SPACECRAFT CHARGING
Minor Subject Terms:
MATHEMATICAL MODELS PROTON IMPACT SECONDARY EMISSION SPACE PLASMAS
Language Note: English

TITLE: ***Additional extensions to the NASCAP computer code, volume 1***

Document ID: **19820017934** N (82N25810) **File Series**: NASA Technical Reports
Report Number: NASA-CR-167855 NAS 1.26:167855 SSS-R-82-5249-REV
Sales Agency & Price: CASI Hardcopy A11 CASI Microfiche A03
Authors:
Mandell, M. J. (Systems Science and Software) Katz, I. (Systems Science and Software) Stannard, P. R. (Systems Science and Software)
Published: Oct 01, 1981
Corporate Source:
Systems Science and Software (San Diego, CA, United States)
Pages: 246
Contract Number: NAS3-22536
NASA Subject Category: COMPUTER PROGRAMMING AND SOFTWARE
Abstract:
Extensions and revisions to a computer code that comprehensively analyzes problems of spacecraft charging (NASCAP) are documented. Using a fully three dimensional approach, it can accurately predict spacecraft potentials under a variety of conditions. Among the extensions are a multiple electron/ion gun test tank capability, and the ability to model anisotropic and time dependent space environments. Also documented are a greatly extended MATCHG program and the preliminary version of NASCAP/LEO. The interactive MATCHG code was developed into an extremely powerful tool for the study of material-environment interactions. The NASCAP/LEO, a three dimensional code to study current collection under conditions of high voltages and short Debye lengths, was distributed for preliminary testing.
Major Subject Terms:
AEROSPACE ENVIRONMENTS COMPUTER PROGRAMS SPACECRAFT CHARGING
Minor Subject Terms:
COMPUTER PROGRAMMING COMPUTERIZED SIMULATION CURRENT DENSITY ELECTRON GUNS FORTRAN PLOTTING SECONDARY EMISSION SPACE ENVIRONMENT SIMULATION
Language Note: English

TITLE: ***Ion thruster charge-exchange plasma flow***

Document ID: **19820036267** A (82A19802) **File Series**: Open Literature
Report Number: AIAA PAPER 82-0403
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Carruth, M. R., Jr. (NASA Marshall Space Flight Center) Gabriel, S. B. (California Institute of Technology, Jet Propulsion Laboratory, Electrical Power and Propulsion Section, Pasadena) Kitamura, S. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, CA)

Published: Jan 01, 1982
Corporate Source:

NASA Marshall Space Flight Center (Huntsville, AL, United States)
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
National Aerospace Lab. (Tokyo, Japan)

Pages: 12
Contract Number: NAS7-100
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

The electron bombardment ion thruster has been under development for a number of years and during this time, studies of the plasmas produced by the thrusters and their interactions with spacecraft have been evaluated, based on available data. Due to diagnostic techniques used and facility effects, there is uncertainty as to the reliability of data from these early studies. This paper presents data on the flow of the charge-exchange plasma produced just downstream of the thruster's ion optics. The 'end-effect' of a cylindrical Langmuir probe is used to determine ion density and directed ion velocity. Results are compared with data obtained from a retarding potential analyzer-Faraday cup.

Major Subject Terms:

CHARGE EXCHANGE ELECTRON BOMBARDMENT ELECTROSTATIC PROBES ION ENGINES MAGNETOHYDRODYNAMIC FLOW

Minor Subject Terms:

FLOW VELOCITY ION DENSITY (CONCENTRATION) IONIC MOBILITY PLASMA DENSITY ROCKET ENGINES SATELLITE ATTITUDE CONTROL SPACE ENVIRONMENT SIMULATION SPACECRAFT ENVIRONMENTS VACUUM CHAMBERS

Language Note: English
Notes:

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 20th, Orlando, FL, Jan. 11-14, 1982, 12 p.

Aerospace Sciences Meeting Orlando, FL Jan. 11-14, 1982

TITLE: ***Review of biased solar array - Plasma interaction studies***

Document ID: **19820037338** A (82A20873) **File Series**: Open Literature
Report Number: AIAA PAPER 81-0738
Sales Agency & Price: Issuing Activity
Authors:
Stevens, N. J. (NASA Lewis Research Center)
Published: Apr 01, 1981
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 16
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Possible high voltage surface interactions on the Solar Electric Propulsion System (SEPS) are examined, with particular regard for potential effects on SEPS performance. The SEPS is intended for use for geosynchronous and planetary missions, and derives power from deployed solar cell arrays which are susceptible to collecting ions and electrons from the charged and thermal particle environment of space. The charge exchange plasma which provides the thrust force can also enhance the natural charged particle environment and increase interactions between the thrust system and the biased solar array surface. Tests of small arrays have shown that snapover, where current collection becomes proportional to the panel area, can be avoided by larger cell sizes. Arcing is predicted to diminish with larger array sizes, while the problems of efflux environments are noted to be as yet undefined and require further study.
Major Subject Terms:
BIAS PLASMA INTERACTIONS SOLAR ARRAYS SOLAR ELECTRIC PROPULSION SPACE ENVIRONMENT SIMULATION SPACECRAFT CHARGING
Minor Subject Terms:
CHARGED PARTICLES ELECTRICAL RESISTANCE GROUND TESTS HIGH VOLTAGES PLASMA POTENTIALS
Language Note: English
Notes:
AIAA, Japan Society for Aeronautical and Space Sciences, and DGLR, International Electric Propulsion Conference, 15th, Las Vegas, NV, Apr. 21-23, 1981, AIAA 16 p.
International Electric Propulsion Conference Las Vegas, NV Apr. 21-23, 1981

TITLE: ***Observation of electromagnetic radiation at twice the electron plasma frequency generated by beam-plasma interactions***

Document ID: **19820040383** A (82A23918) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Leung, P. Santoru, J. Wong, A. Y. Cheung, P. Y. (California, University)

Published: Jan 01, 1981
Corporate Source:

(Corporate Source(s) Not Available)

Pages: 6
Contract Number: NSF PHY-79-08480
NASA Subject Category: PLASMA PHYSICS
Abstract:

A laboratory experiment is described in which electromagnetic radiation at twice the electron plasma frequency is generated by the interaction of electron plasma waves excited by electron beams. The power of the electron plasma frequency radiation is found to scale with the fourth power of the electrostatic wave amplitude and to be consistent with the prediction of a wave-wave coupling model. The Langmuir wave spectrum is observed to broaden, indicating that the waves undergo parametric decay. The forward propagating waves are thus backscattered by ion-acoustic or zero-frequency density perturbations to generate backward propagating waves. The result is that the antiparallel plasma waves are able to interact to generate electron plasma frequency radiation, as in the two-beam case.

Major Subject Terms:

BEAM PLASMA AMPLIFIERS ELECTROMAGNETIC RADIATION ELECTRON BEAMS PLASMA INTERACTIONS PLASMA WAVES WAVE PROPAGATION

Minor Subject Terms:

BACKSCATTERING ELECTROSTATIC PROBES ELECTROSTATIC WAVES MAGNETOHYDRODYNAMIC STABILITY TRANSVERSE WAVES

Language Note: English
Notes:

In: Physics of auroral arc formation; Proceedings of the Chapman Conference on Formation of Auroral Arcs, Fairbanks, AK, July 21-25, 1980. (A82-23876 09-46) Washington, DC, American Geophysical Union, 1981, p. 387-392.

Physics of auroral arc formation Fairbanks, AK July 21-25, 1980

TITLE: ***Plasma flow measurements in a simulated low earth orbit plasma***

Document ID: **19820053928** A (82A37463) **File Series**: Open Literature
Report Number: AIAA PAPER 82-0925
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Gabriel, S. B. (California Institute of Technology, Jet Propulsion Laboratory, Electrical Power and Propulsion Section, Pasadena) Mccoy, J. E. (NASA Johnson Space Center) Carruth, M. R., Jr. (NASA Marshall Space Flight Center)

Published: Jun 01, 1982
Corporate Source:

Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
NASA Marshall Space Flight Center (Huntsville, AL, United States)
NASA Lyndon B. Johnson Space Center (Houston, TX, United States)

Pages: 8
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:

The employment of large, higher power solar arrays for space operation has been considered, taking into account a utilization of high operating voltages. In connection with the consideration of such arrays, attention must be given to the fact that the ambient environment of space contains a tenuous low energy plasma which can interact with the high voltage array causing power 'leakage' and arcing. An investigation has been conducted with the aim to simulate the behavior of such an array in low-earth-orbit (LEO). During the experiments, local concentrations of the 'leakage' current were observed when the panel was at a high voltage. These concentrations could overload or damage a small area of cells in a large string. It was hypothesized that this effect was produced by electrostatic focusing of the particles by the sheath fields. To verify this experimentally, an end-effect Langmuir probe was employed. The obtained results are discussed.

Major Subject Terms:

EARTH ORBITS ELECTROSTATIC PROBES FLOW MEASUREMENT LOW EARTH ORBITS MAGNETOHYDRODYNAMIC FLOW PLASMA SHEATHS SPACE PLASMAS

Minor Subject Terms:

EARTH IONOSPHERE FLOW CHARACTERISTICS FLOW VELOCITY PLASMA DENSITY SOLAR ARRAYS

Language Note: English
Notes:

American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference, 3rd, St. Louis, MO, June 7-11, 1982, AIAA 8 p. NASA-supported research.

Joint Thermophysics, Fluids, Plasma and Heat Transfer Conference St. Louis, MO June 7-11, 1982

TITLE: ***SAFE II: Large systems space plasma evaluation experiment***

Document ID: **19830018632** N (83N26903) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI A03
Authors:

Carruth, M. R., Jr. (NASA Marshall Space Flight Center) Young, L. E. (NASA Marshall Space Flight Center) Purvis, C. K. (NASA Marshall Space Flight Center) Stevens, N. J. (NASA Marshall Space Flight Center)

Journal Title: NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 **Page**: p 991-1006
Published: May 01, 1983
Corporate Source:

NASA Marshall Space Flight Center (Huntsville, AL, United States)
NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 16
Contract Number: None
NASA Subject Category: LAUNCH VEHICLES AND SPACE VEHICLES
Abstract:

A shuttle flight experiment, the purpose of which is to obtain space data on the interaction of a high voltage solar array with the ambient space plasma is addressed. This flight experiment is a reflight of the solar array flight experiment, SAFE, except that three active solar array panels, electron release devices and plasma diagnostics are added. This experiment, SAFE 2, evaluates power loss due to parasitic current collected by the solar array, arcing on the solar array and perturbations to the plasma which may increase power loss and disturb plasma and charged particle science acquisition.

Major Subject Terms:

ENERGY DISSIPATION HIGH VOLTAGES PLASMA DIAGNOSTICS PLASMA INTERACTIONS SOLAR ARRAYS SPACE PLASMAS

Minor Subject Terms:

EXPERIMENT DESIGN PERTURBATION SOLAR CELLS SPACEBORNE EXPERIMENTS

Language Note: English
Notes:

In NASA. Langley Research Center Large Space Antenna Systems Technol., Pt. 2 p 991-1006 (SEE N83-26879 16-15)

Prepared in cooperation with NASA. Lewis Research Center

TITLE: ***A comparison of the MSIS and Jacchia-70 models with measured atmospheric density data in the 120 to 200 km altitude range***

Document ID: 19830023945 N (83N32216) **File Series**: NASA Technical Reports

Report Number: AD-A128005 SD-TR-83-25 TR-0083(3940-04)-1

Sales Agency & Price: CASI Hardcopy A07 CASI Microfiche A02

Authors:

Prag, A. B. (Aerospace Corp.)

Published: Apr 20, 1983

Corporate Source:

Aerospace Corp. (El Segundo, CA, United States)

Pages: 149

Contract Number: F04701-82-C-0083

NASA Subject Category: GEOPHYSICS

Abstract:

The MSIS and **Jacchia**-70 (J70) models have been evaluated at each of the nearly 55,000 points for which we have measurements of the atmospheric density between 120 and 200 km. The density measurements were made by nine different instruments of five types (ion gauge, capacitance manometer, mass spectrometer, calorimeter, and accelerometer) flown of five satellites during the 1974-1977 solar minimum. Except for the solar flux, all the parameters used in the models (geomagnetic activity, altitude, latitude, local time, season, etc.) were well represented. The density measurements at any one altitude were found to be consistent with a lognormal distribution; that is, the fractional variations in the density were normally distributed, rather than the variations themselves. If a model correctly predicted the average variation in density, the log of the ratio of the measurements to the predictions should be normally distributed with skewness of 0.0 and kurtosis of 3.0. In fact, the skewness when the J70 model was used was -0.10 and the kurtosis was 3.51. For the MSIS model, the corresponding numbers were -0.06 and 4.42.

Major Subject Terms:

ALTITUDE ATMOSPHERIC DENSITY HISTOGRAMS LATITUDE THERMOSPHERE

Minor Subject Terms:

ACCELEROMETERS CALORIMETERS MASS SPECTROMETERS MEASURING INSTRUMENTS

Language Note: English

TITLE: ***A three-dimensional wake model for low earth orbit***

Document ID: **19830035424** A (83A16642) **File Series**: Open Literature
Report Number: AIAA PAPER 83-0309
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Katz, I. Cooke, D. L. Parks, D. E. Mandell, M. J. (S-CUBED) Rubin, A. G. (USAF, Geophysics Laboratory, Bedford)
Published: Jan 01, 1983
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 6
Contract Number: F19628-82-C-0081
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
A calculation of the electrostatic potential surrounding the AE-C spacecraft which ignores ion focusing effects on space charge density is presented as part of the development of the POLAR computer code as a three-dimensional model of the electrostatic interaction between a spacecraft and its ionospheric environment. Results show that the potential in the near wake is dominated by negative charge accumulated on the spacecraft's dielectric surfaces. No potential minimum in the near wake is found in this case. The wake potentials and ion currents predicted by this model are compared with those obtained from AE-C data by Samir et al. (1979). Good agreement is found between the measurements and the values calculated by using this theory.
Major Subject Terms:
EARTH ORBITS IONOSPHERIC ION DENSITY LOW EARTH ORBITS SATELLITE ORBITS SPACECRAFT CHARGING THREE DIMENSIONAL MODELS WAKES
Minor Subject Terms:
COMPUTER PROGRAMS ELECTRIC POTENTIAL ELECTROSTATICS EXPLORER 51 SATELLITE NEAR WAKES POISSON EQUATION
Language Note: English
Notes:
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 21st, Reno, NV, Jan. 10-13, 1983, 6 p.
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting Reno, NV Jan. 10-13, 1983

TITLE: ***Potentials on large spacecraft in LEO***

Document ID: **19830036271** A (83A17489) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Mandell, M. J. Katz, I. Cooke, D. L.
Published: Dec 01, 1982
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 5
Contract Number: NAS3-22826
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
A system-oriented computer code is used to predict surface charging due to voltages generated within a satellite operating in the typical dense plasma environment of LEO. The use of this code is demonstrated by predicting the expansion of electric fields onto a kapton surface from a pinhole over a biased conductor in a LEO environment. The results are compared to a more-exact solution and experimental data.
Major Subject Terms:
ARTIFICIAL SATELLITES COLD PLASMAS ELECTRIC POTENTIAL SPACECRAFT CHARGING
Minor Subject Terms:
COMPUTERIZED SIMULATION EARTH ORBITS GEOSYNCHRONOUS ORBITS KAPTON (TRADEMARK) SPACE PLASMAS
Language Note: English
Notes:
(IEEE, DOD, NASA, and DOE, Annual Conference on Nuclear and Space Radiation Effects, 19th, Las Vegas, NV, July 20-22, 1982.) IEEE Transactions on Nuclear Science, vol. NS-29, Dec. 1982, p. 1584-1588.

TITLE: ***Dual maxwellian space plasma modeling by the logarithmic method***

Document ID: **19840012319** N (84N20387) **File Series**: NASA Technical Reports
Report Number: AD-A137131 AFGL-TR-83-0169 AFGL-PSRP-667
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Besse, A. L. (Air Force Geophysics Lab.) Rubin, A. G. (Air Force Geophysics Lab.) Tautz, M. F. (Air Force Geophysics Lab.)
Published: Jul 05, 1983
Corporate Source:
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 14
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
A common and useful practice in the study of spacecraft charging phenomena is the use of dual Maxwellian models of the particle distributions. These models frequently employ a least error fit to the logarithm of the measured distribution function over an energy range that may exceed three decades. By example, we demonstrate that the resulting models are not satisfactory for the calculation of spacecraft charging. The models do not have a sufficient number of adjustable parameters to fit the measured spectra over such a wide energy range. More satisfactory models are obtained by weighting the spectral data according to their relevance to the spacecraft charging phenomena under investigation. In addition, reasonable limits must be placed on the temperatures of the models to prevent the artifacts that have been experienced in a minority of cases.
Major Subject Terms:
LOGARITHMS SPACE CHARGE
Minor Subject Terms:
DISTRIBUTION FUNCTIONS FUNCTIONS (MATHEMATICS) MATHEMATICAL MODELS MAXWELL EQUATION PLASMA SPECTRA
Language Note: English

TITLE: ***Shuttle Orbiter charging in polar Earth orbit***

Document ID: **19840018134** N (84N26202) **File Series**: NASA Technical Reports
Report Number: AD-P002116
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A04
Authors:
Rubin, A. G. (Air Force Geophysics Lab.) Besse, A. L. (Air Force Geophysics Lab.)
Journal Title: Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit **Page**: p 253-263
Published: Jan 25, 1983
Corporate Source:
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 11
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Spacecraft in polar orbit are subject to charging by the intense electron stream that comprises the aurora. Charging is computed according to the Laframboise theory of plasma probes in which the variation of sheath thickness with potential is taken into account. In this environment spacecraft charge to potentials that depend on their size. It is shown that large spacecraft charge to higher potentials than small spacecraft. The shuttle orbiter being a large spacecraft, may charge to more than 6 kV passing through an intense beam of auroral electrons. Because of the deficiency of ambient ions in the near wake region, the rear of the vehicle will have the lowest threshold auroral current for charging and will charge to the highest potential.
Major Subject Terms:
AURORAL IONIZATION ELECTRIC POTENTIAL EXTERNAL SURFACE CURRENTS PLASMA PROBES PLASMA SHEATHS POLAR ORBITS SPACECRAFT CHARGING
Minor Subject Terms:
ELECTRON FLUX DENSITY ION DENSITY (CONCENTRATION) IONOSPHERIC CURRENTS SPACE SHUTTLE ORBITERS TAIL SURFACES WAKES
Language Note: English
Notes:
In its Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 253-263 (SEE N84-26185 16-46)

TITLE: ***High voltage solar array models and Shuttle tile charging***

Document ID: **19840018141** N (84N26209) **File Series**: NASA Technical Reports
Report Number: AD-P002123
Sales Agency & Price: CASI A03
Authors:
Rubin, A. G. (NASA Lewis Research Center) Stevens, N. J. (NASA Lewis Research Center)
Journal Title: AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit **Page**: p 333-336
Published: Jan 25, 1983
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 3
Contract Number: None
NASA Subject Category: COMPUTER PROGRAMMING AND SOFTWARE
Abstract:
This paper described NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) a 3-D computer code that simulates the interaction of space plasma with high-voltage solar arrays in the thin plasma sheath regime. The code requires information about the object and the ambient plasma. The geometric description, the material composition and the voltage distribution versus time of a solar array are the data required about the object. The plasma properties needed are the composition, density, and temperature. NASCAP/LEO will then provide the time-dependent current to each element of area of the array from the external plasma. The NASCAP/LEO output is provided in both three dimensional computer graphics and in numerical form. NASCAP/LEO is user oriented and will provide potential distributions around the object, the currents to each of the conductors, and graphical details of the sheaths and particle trajectories.
Major Subject Terms:
COMPUTER PROGRAMS COMPUTERIZED SIMULATION HIGH VOLTAGES PLASMA INTERACTIONS PLASMA SHEATHS SOLAR ARRAYS SPACE PLASMAS SPACECRAFT CHARGING
Minor Subject Terms:
CHARGE DISTRIBUTION COMPUTER GRAPHICS GEOMETRY LOW EARTH ORBITS PARTICLE TRAJECTORIES PLASMA DIAGNOSTICS SPACECRAFT CONSTRUCTION MATERIALS TIME DEPENDENCE
Language Note: English
Notes:
In AFGL Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 333-336 (SEE N84-26185 16-46)
Prepared in cooperation with AFGL, Hanscom AFB, Mass.

TITLE: ***Space systems environmental interactions technology program***

Document ID: **19840018143** N (84N26211) **File Series**: NASA Technical Reports
Report Number: AD-P002125
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:

Pike, C. P. (Air Force Geophysics Lab.) Guidice, D. A. (Air Force Geophysics Lab.) Davis, R. A. (Air Force Geophysics Lab.) Chesley, A. L. (Air Force Geophysics Lab.) Hall, W. N. (Air Force Geophysics Lab.) Shuman, B. M. (Air Force Geophysics Lab.)

Journal Title: Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit **Page**: p 391-398
Published: Jan 25, 1983
Corporate Source:

Air Force Geophysics Lab. (Hanscom AFB, MA, United States)

Pages: 8
Contract Number: None
NASA Subject Category: ASTRONAUTICS (GENERAL)
Abstract:

The technology program described here addresses space environmental interactions on large dimension high power satellites to provide technology solutions that will insure against potential system failure. Topics under investigation include auroral plasma interaction with high voltage solar arrays, effects of polar magnetic fields on large space structures, electromagnetic interference with space communications and surveillance, and systems failures during extravehicular activity that threaten the astronaut.

Major Subject Terms:

DESIGN ANALYSIS ENVIRONMENT EFFECTS LARGE SPACE STRUCTURES PLASMA INTERACTIONS PROJECT MANAGEMENT RESEARCH MANAGEMENT SPACE PLASMAS SPACECRAFT CHARGING SYSTEMS ANALYSIS

Minor Subject Terms:

ELECTROMAGNETIC INTERFERENCE EXTRAVEHICULAR ACTIVITY EXTRAVEHICULAR MOBILITY UNITS HIGH VOLTAGES MAGNETIC FIELDS PROJECT PLANNING SOLAR ARRAYS

Language Note: English
Notes:

In its Proc. of the AFGL Workshop on Nat. Charging of Large Space Struct. in Near Earth Polar Orbit p 391-398 (SEE N84-26185 16-46)

TITLE: ***Characteristics of arc currents on a negatively biased solar cell array in a plasma***

Document ID: **19840019755** N (84N27824) **File Series**: NASA Technical Reports
Report Number: NASA-TM-83728 E-2170 NAS 1.15:83728
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Snyder, D. B. (NASA Lewis Research Center)
Published: Jan 01, 1984
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 12
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The time dependence of the emitted currents during arcing on solar cell arrays is being studied. The arcs are characterized using three parameters: the voltage change of the array during the arc (i.e., the charge lost), the peak current during the arc, and the time constant describing the arc current. This paper reports the dependence of these characteristics on two array parameters, the interconnect bias voltage and the array capacitance to ground. It was found that the voltage change of the array during an arc is nearly equal to the bias voltage. The array capacitance, on the other hand, influences both the peak current and the decay time constant of the arc. Both of these characteristics increase with increasing capacitance.
Major Subject Terms:
ARC DISCHARGES CAPACITANCE PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS
Minor Subject Terms:
ELECTRIC POTENTIAL PLASMA PHYSICS TIME DEPENDENCE
Language Note: English
Notes:
Presented at the Nucl. and Space Radiation Effects Conf., Colorado Springs, 22-25 Jul. 1984
Nucl. and Space Radiation Effects Conf. Colorado Springs, CO 22-25 Jul. 1984

TITLE: ***Solar array: Plasma interactions***

Document ID: **19840021274** N (84N29343) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Purvis, C. K. (NASA Lewis Research Center)
Journal Title: Space Photovoltaic Res. and Technol. 1983 **Page**: p 236
Published: Jan 01, 1984
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 1
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
Interactions between space systems and their orbital particle and field environments have significant impact on the system's operation and life. Interactions such as radiation damage and aerodynamic drag are considered in designing space systems. There are, however, a number of orbital environmental interactions which become important design considerations only for large or high power systems. Their impact is assessed to ensure successful design. Interactions between higher voltage solar arrays and the space plasma which are of critical concern in designing large orbital photovoltaic power systems are outlined.
Major Subject Terms:
AERODYNAMIC DRAG AEROSPACE SYSTEMS ELECTROMAGNETIC FIELDS ORBITS PLASMA INTERACTIONS SOLAR ARRAYS
Minor Subject Terms:
RADIATION DAMAGE SOLAR ORBITS SPACE PLASMAS SPACECRAFT ORBITS SYSTEMS ENGINEERING
Language Note: English
Notes:
In its Space Photovoltaic Res. and Technol. 1983 p 236 (SEE N84-29307 19-44)

TITLE: ***Design guidelines for assessing and controlling spacecraft charging effects***

Document ID: **19840025381** N (84N33452) **File Series**: NASA Technical Reports
Report Number: NASA-TP-2361 E-2073 NAS 1.60:2361
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Purvis, C. K. (NASA Lewis Research Center) Garrett, H. B. (JPL) Whittlesey, A. C. (JPL) Stevens, N. J. (Hughes Aircraft Co.)
Published: Sep 01, 1984
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 48
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The need for uniform criteria, or guidelines, to be used in all phases of spacecraft design is discussed. Guidelines were developed for the control of absolute and differential charging of spacecraft surfaces by the lower energy space charged particle environment. Interior charging due to higher energy particles is not considered. A guide to good design practices for assessing and controlling charging effects is presented. Uniform design practices for all space vehicles are outlined.
Major Subject Terms:
ELECTROMAGNETIC COMPATIBILITY ELECTROMAGNETIC PULSES GEOSYNCHRONOUS ORBITS SPACECRAFT CHARGING SPACECRAFT DESIGN
Minor Subject Terms:
DESIGN ANALYSIS EXTERNAL SURFACE CURRENTS SPACECRAFT ORBITS STANDARDS
Language Note: English

TITLE: ***Plasma sheath structure surrounding a large powered spacecraft***

Document ID: **19840035238** A (84A18025) **File Series**: Open Literature
Report Number: AIAA PAPER 84-0329
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Mandell, M. J. (Systems Science and Software) Jongeward, G. A. (Systems Science and Software) Katz, I. (System, Science and Software, La Jolla)

Published: Jan 01, 1984
Corporate Source:

Systems Science and Software (La Jolla, CA, United States)

Pages: 5
Contract Number: NAS3-23058
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

Various factors determining the floating potential of a highly biased (about 4-kV) spacecraft in low earth orbit are discussed. While the common rule of thumb (90 percent negative; 10 percent positive) is usually a good guide, different biasing and grounding patterns can lead to high positive potentials. The NASCAP/LEO code can be used to predict spacecraft floating potential for complex three-dimensional spacecraft.

Major Subject Terms:

PLASMA INTERACTIONS PLASMA SHEATHS SPACECRAFT DESIGN SPACECRAFT ENVIRONMENTS SPACECRAFT POWER SUPPLIES

Minor Subject Terms:

ELECTRIC POTENTIAL HIGH VOLTAGES LOW EARTH ORBITS SOLAR ARRAYS

Language Note: English
Notes:

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 22nd, Reno, NV, Jan. 9-12, 1984. 5 p.

TITLE: ***Potentials in a plasma over a biased pinhole***

Document ID: **19840037924** A (84A20711) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Mandell, M. J. (Systems Science and Software) Katz, I. (Systems, Science and Software, La Jolla)
Journal Title: IEEE Transactions on Nuclear Science **Volume**: NS-30 **Page**: 4307-431
Published: Dec 01, 1983
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 4
Contract Number: NAS3-23058
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:
The NASCAP/LEO code is used to simulate measurements taken at Jet Propulsion Laboratory of potentials near a simulated pinhole. The insulator near the high-voltage pinhole obeys an electric field boundary condition resulting from secondary electron hopping conductivity. The code predictions are in good agreement with the measurements.
Major Subject Terms:
COMPUTERIZED SIMULATION ELECTRICAL MEASUREMENT HIGH VOLTAGES PINHOLES PLASMA POTENTIALS
Minor Subject Terms:
COULOMB POTENTIAL ELECTRON IRRADIATION ERROR ANALYSIS INSULATORS PLASMA DIAGNOSTICS SPACECRAFT CHARGING
Language Note: English
Notes:
(IEEE, U.S. Defense Nuclear Agency, NASA, et al., Annual Conference on Nuclear and Space Radiation Effects, Gatlinburg, TN, July 18-21, 1983) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-30, Dec. 1983, p. 4307-4310.

TITLE: ***Discharge characteristics of a simulated solar cell array***

Document ID: **19840037925** A (84A20712) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Leung, P. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena)
Journal Title: IEEE Transactions on Nuclear Science **Volume**: NS-30 **Page**: 4311-431
Published: Dec 01, 1983
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 5
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
Measurements of the transient characteristics associated with the discharge of a simulated solar array are presented. A capacitively coupled probe is used to measure the discharge current, and antennas are used to measure the electromagnetic radiation. Discharges were observed at low surface voltages and several modes of discharge were observed. The maximum discharge current is found to be 0.2 A. This value is several orders of magnitude higher than that reported by previous measurements. Experimental evidence suggests that the inverted voltage gradient is a very likely triggering mechanism for solar array discharges.
Major Subject Terms:
ELECTRIC DISCHARGES ELECTRICAL MEASUREMENT SOLAR ARRAYS SOLAR CELLS SPACECRAFT CHARGING
Minor Subject Terms:
RADIO FREQUENCY DISCHARGE SIMULATION SPACECRAFT ENVIRONMENTS
Language Note: English
Notes:
(IEEE, U.S. Defense Nuclear Agency, NASA, et al., Annual Conference on Nuclear and Space Radiation Effects, Gatlinburg, TN, July 18-21, 1983) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-30, Dec. 1983, p. 4311-4315. NASA-supported research.
NASA-supported research

TITLE: ***Measurements of the thermal plasma environment of the Space Shuttle***

Document ID: 19840045345 A (84A28132) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Raitt, W. J. (Utah State Univ.) Siskind, D. E. (Utah State University) Banks, P. M. (Utah State Univ.) Williamson, P. R. (Stanford University)
Journal Title: Planetary and Space Science **Volume**: 32 **Page**: 457-467
Published: Apr 01, 1984
Corporate Source:
Utah State Univ. (Logan, UT, United States)
Stanford Univ. (CA, United States)
Pages: 11
Contract Number: NAS5-24455
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The paper presents some initial results on measurements of the thermal plasma environment obtained by a spherical retarding potential analyzer and a Langmuir probe flown on (STS-3) as part of the NASA Office of Space Science-1 payload in March 1982. One of the major effects observed is a higher degree of turbulence in the ambient plasma compared to what is observed from similar instruments flown on unmanned satellites. In addition we see the temperature of the thermal electrons elevated to values of 4000-5000 K. Associated with elevated electron temperatures are regions of enhanced plasma density resulting from the appearance of high densities of molecular ions. The thermal plasma data also show clear effects of an induced V x B.L potential at the location of the probes which matches that produced by an L vector linking the probes to the engine nozzles; thereby establishing the prime return current location on the Orbiter. The final observations discussed are the pronounced and complex **wake** effects resulting both from the main structure of the Orbiter and from the complex shapes of appendages attached to the Orbiter.
Major Subject Terms:
AEROSPACE ENVIRONMENTS ELECTROSTATIC PROBES PLASMA DIAGNOSTICS SPACE PLASMAS SPACE TRANSPORTATION SYSTEM 3 FLIGHT THERMAL PLASMAS
Minor Subject Terms:
EARTH IONOSPHERE ELECTRON ENERGY ION DENSITY (CONCENTRATION) OSS-1 PAYLOAD PLASMA DENSITY PLASMA POTENTIALS PLASMA TURBULENCE SIGNATURES VOLT-AMPERE CHARACTERISTICS WAKES
Language Note: English
Notes:
Planetary and Space Science (ISSN 0032-0633), vol. 32, April 1984, p. 457-467.

TITLE: ***The effect of plasma on solar cell array arc characteristics***

Document ID: **19850002825** N (85N11133) **File Series**: NASA Technical Reports
Report Number: NASA-TM-86887 • E-2351 • NAS 1.15:86887
Sales Agency & Price: CASI Hardcopy A03 • CASI Microfiche A01
Authors:
Snyder, D. B. (NASA Lewis Research Center) • Tyree, E. (NASA Lewis Research Center)
Published: Jan 01, 1984
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 17
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The influence from the ambient plasma on the arc characteristics of a negatively biased solar cell array was investigated. The arc characteristics examined were the peak current during an arc, the decay time as the arc terminates, and the charge lost during the arc. These arc characteristics were examined in a nitrogen plasma with charge densities ranging from 15,000 to 45,000 cu cm. Background gas pressures ranged from 8x1,000,000 to 6x100,000 torr. Over these ranges of parameters no significant effect on the arc characteristics were seen. Arc characteristics were also examined for three gas species: helium, nitrogen and argon. The helium arcs have higher peak currents and shorter decay times than nitrogen and argon arcs. There are slight differences in the arc characteristics between nitrogen and argon. These differences may be caused by the differences in mass of the respective species. Also, evidence is presented for an electron emission mechanism appearing as a precursor to solar array arcs. Occassionally the plasma generator could be turned off, and currents could still be detected in the vacuum system. When these currents are presented, arcs may occur.
Major Subject Terms:
PLASMA INTERACTIONS • PLASMA JETS • SOLAR CELLS
Minor Subject Terms:
ARC DISCHARGES • ARGON • ELECTRON EMISSION • GAS PRESSURE • HELIUM • NITROGEN PLASMA • PLASMA CURRENTS • PLASMA DECAY
Language Note: English
Notes:
Proposed for presentation at the 23rd Aerospace Sci. Meeting, Reno, Nev., 14-17 Jan. 1985; sponsored by the American Inst. of Aeronautics and Astronautics
Aerospace Sci. Meeting Reno, NV 14-17 Jan. 1985

TITLE: ***Electrodynamic tethers. 1: Power generator in LEO. 2: Thrust for propulsion and power storage***

Document ID: **19850005592** N (85N13901) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI A02
Authors:
Mccoy, J. E. (NASA Lyndon B. Johnson Space Center)
Journal Title: NASA. Lewis Research Center Space Power **Page**: p 275-284
Published: Apr 01, 1984
Corporate Source:
NASA Lyndon B. Johnson Space Center (Houston, TX, United States)
Pages: 10
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
An electrodynamic tether consists of a long insulated wire in space whose orbital motion cuts across lines of magnetic flux to produce an induce voltage that in typical low orbits averages about 200 v/km. Such a system should be capable of generating substantial electrical power, at the expense of IXB drag acting on its orbital energy. If a reverse current is driven against the induced voltage, the system should act as a motor producing IXB thrust. A reference system was designed, capable of generating 20 KW of power into an electrical load located anywhere along the wire at the expense of 2.6N (20,000 J/sec) drag on the wire. In an ideal system, the conversion between mechanical and electrical energy would reach 100% efficiency. In the actual system part of the 20 KW is lost to internal resistance of the wire, plasma and ionosphere, while the drag force is increased by residual air drag. The 20 KW PMG system as designed is estimated to provide 18.7 KW net power to the load at total drag loss of 20.4 KJ/sec, or an overall efficiency of 92%. Similar systems using heavier wire appear capable of producing power levels in excess of 1 Megawatt at voltages of 2-4 KV, with conversion efficiency between mechanical and electrical power better than 95%. The hollow cathode based system should be readily reversible from generator to motor operation by driving a reverse current using onboard power.
Major Subject Terms:
ELECTRIC ENERGY STORAGE ELECTRODYNAMICS SPACECRAFT POWER SUPPLIES SPACECRAFT PROPULSION TETHERED SATELLITES TETHERLINES
Minor Subject Terms:
COUPLING DYNAMIC STABILITY EARTH IONOSPHERE ELECTROSTATIC DRAG PERFORMANCE PREDICTION
Language Note: English
Notes:
In NASA. Lewis Research Center Space Power p 275-284 (SEE N85-13880 05-20)

TITLE: ***Three-dimensional calculation of shuttle charging in polar orbit***

Document ID: **19850014175** N (85N22486) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:

Cooke, D. L. (NASA Lewis Research Center) Katz, I. (NASA Lewis Research Center) Mandell, M. J. (NASA Lewis Research Center) Lilley, J. R., Jr. (NASA Lewis Research Center) Rubin, A. J. (AFGL)

Journal Title: NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 **Page**: p 205-227
Published: Mar 01, 1985
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 23
Contract Number: F19628-82-C-0081
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

The charged particles environment in polar orbit can be of sufficient intensity to cause spacecraft charging. In order to gain a quantitative understanding of such effects, the Air Force is developing POLAR, a computer code which simulates in three dimensions the electrical interaction of large space vehicles with the polar ionospheric plasma. It models the physical processes of wake generation, ambient ion collection, precipitating auroral electron fluxes, and surface interactions, including secondary electron generation and backscattering, which lead to vehicle charging. These processes may be followed dynamically on a subsecond timescale so that the rapid passage through intense auroral arcs can be simulated. POLAR models the ambient plasma as isotropic Maxwellian electrons and ions (0+, H+), and allows for simultaneous precipitation of power-law, energetic Maxwellian, and accelerated Gaussian distributions of electrons. Magnetic field effects will be modeled in POLAR but are currently ignored.

Major Subject Terms:

COMPUTER PROGRAMS COMPUTERIZED SIMULATION ELECTRON FLUX DENSITY HYDROGEN IONS IONOSPHERIC CURRENTS MODELS OXYGEN IONS POLAR ORBITS SPACE PLASMAS SPACECRAFT CHARGING SURFACE REACTIONS

Minor Subject Terms:

AURORAL ARCS MAGNETIC EFFECTS MAGNETIC FIELDS SPACE SHUTTLES

Language Note: English
Notes:

In NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 205-227 (SEE N85-22470 13-18)

TITLE: ***Surface interactions and high-voltage current collection***

Document ID: **19850014182** N (85N22493) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:

Mandell, M. J. (Systems Science and Software) Katz, I. (Systems Science and Software)

Journal Title: NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 **Page**: p 305-320
Published: Mar 01, 1985

Corporate Source:

Systems Science and Software (La Jolla, CA, United States)

Pages: 15
Contract Number: NAS3-23058
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

Spacecraft of the future will be larger and have higher power requirements than any flown to date. For several reasons, it is desirable to operate a high power system at high voltage. While the optimal voltages for many future missions are in the range 500 to 5000 volts, the highest voltage yet flown is approximately 100 volts. The NASCAP/LEO code is being developed to embody the phenomenology needed to model the environmental interactions of high voltage spacecraft. Some plasma environment are discussed. The treatment of the surface conductivity associated with emitted electrons and some simulations by NASCAP/LEO of ground based high voltage interaction experiments are described.

Major Subject Terms:

EXTERNAL SURFACE CURRENTS HIGH CURRENT PLASMA INTERACTIONS SPACE PLASMAS SPACECRAFT CHARGING

Minor Subject Terms:

AEROSPACE ENVIRONMENTS COMPUTER PROGRAMS COMPUTERIZED SIMULATION ELECTRIC POTENTIAL HIGH VOLTAGES INSULATORS SPACE CHARGE

Language Note: English
Notes:

In NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 305-320 (SEE N85-22470 13-18)

TITLE: ***The PIX-2 experiment: An overview***

Document ID: **19850014183** N (85N22494) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:

Purvis, C. K. (NASA Lewis Research Center)

Journal Title: Spacecraft Environ. Interactions Technol. **Page**: p 321-332
Published: Mar 01, 1985
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 11
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:

The second Plasma Interactions Experiment (PIX-2) was launched in January 1983 as a piggyback on the second stage of the Delta launch vehicle that carried IRAS into orbit. Placed in a 870 km circular polar orbit, it returned 18 hrs of data on the plasma current collection and arcing behavior of solar arrays biased to 1000 V in steps. The four 500 sq cm solar array segments were biased singly and in combinations. In addition to the array segments PIX-2 carried a Sun sensor, a Langmuir probe to measure electron currents, and a hot-wire filament electron emitter to control vehicle potential during positive array bias sequences. The PIX-2 experiment is reviewed from program and operational perspectives.

Major Subject Terms:

PLASMA INTERACTION EXPERIMENT PLASMA INTERACTIONS SOLAR ARRAYS SPACE PLASMAS SPACECRAFT CHARGING

Minor Subject Terms:

ELECTRIC ARCS ELECTROSTATIC PROBES HIGH VOLTAGES PLASMA DIAGNOSTICS

Language Note: English
Notes:

In its Spacecraft Environ. Interactions Technol. p 321-332 (SEE N85-22470 13-18)

TITLE: ***Ram-wake effects on plasma current collection of the PIX 2 Langmuir probe***

Document ID: **19850014185** N (85N22496) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:
Ferguson, D. C. (NASA Lewis Research Center)
Journal Title: Spacecraft Environ. Interactions Technol. **Page**: p 349-357
Published: Mar 01, 1985
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 9
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
The Plasma Interaction Experiment 2 (PIX 2) Langmuir probe readings of the same polar magnetospheric regions taken on consecutive orbits showed occasional apparent densities as much as 10 times lower than the average, although each pass clearly showed density structures related to the day/night boundary. At other points in the orbit, Langmuir probe currents varied by as much as a factor of 20 on a time scale of minutes. The hypothesis is advanced that these apparent inconsistencies in Langmuir probe current are the results of the probe's orientation relative to the body of the spacecraft and the velocity vector. Theoretical studies predict a possible depletion in collected electron current by a factor of 100 in the wake. Experimental results from other spacecraft indicate that a wake electron depletion by a factor of 10 or so is realistic. This amount of depletion is consistent with the PIX 2 data if the spacecraft was rotating. Both the Sun sensor and temperature sensor data on PIX 2 show a complex variation consistent with rotation of the Langmuir probe into and out of the spacecraft wake on a time scale of minutes. Furthermore, Langmuir probe data taken when the probe was not in the spacecraft wake are consistent from orbit to orbit. This supports the interpretation that ram/wake effects may be the source of apparent discrepancies at other orientations.
Major Subject Terms:
ELECTROSTATIC PROBES PLASMA CURRENTS PLASMA DENSITY PLASMA DIAGNOSTICS PLASMA INTERACTION EXPERIMENT SPACE PLASMAS WAKES
Minor Subject Terms:
ION DENSITY (CONCENTRATION) RELIABILITY SATELLITE ORIENTATION
Language Note: English
Notes:
In its Spacecraft Environ. Interactions Technol. p 349-357 (SEE N85-22470 13-18)

TITLE: ***NASCAP simulation of PIX 2 experiments***

Document ID: **19850014186** N (85N22497) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:
Roche, J. C. (NASA Lewis Research Center) Mandell, M. J. (Systems)
Journal Title: Spacecraft Environ. Interactions Technol. **Page**: p 359-366
Published: Mar 01, 1985
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 8
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
The latest version of the NASCAP/LEO digital computer code used to simulate the PIX 2 experiment is discussed. NASCAP is a finite-element code and previous versions were restricted to a single fixed mesh size. As a consequence the resolution was dictated by the largest physical dimension to be modeled. The latest version of NASCAP/LEO can subdivide selected regions. This permitted the modeling of the overall Delta launch vehicle in the primary computational grid at a coarse resolution, with subdivided regions at finer resolution being used to pick up the details of the experiment module configuration. Langmuir probe data from the flight were used to estimate the space plasma density and temperature and the Delta ground potential relative to the space plasma. This information is needed for input to NASCAP. Because of the uncertainty or variability in the values of these parameters, it was necessary to explore a range around the nominal value in order to determine the variation in current collection. The flight data from PIX 2 were also compared with the results of the NASCAP simulation.
Major Subject Terms:
COMPUTER PROGRAMS COMPUTERIZED SIMULATION PLASMA DENSITY SPACE PLASMAS
Minor Subject Terms:
DELTA LAUNCH VEHICLE FINITE ELEMENT METHOD
Language Note: English
Notes:
In its Spacecraft Environ. Interactions Technol. p 359-366 (SEE N85-22470 13-18)

TITLE: ***An investigation of arc discharging on negatively biased dielectric conductor samples in a plasma***

Document ID: 19850014187 N (85N22498) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:
Miller, W. L. (NASA Lewis Research Center)
Journal Title: Spacecraft Environ. Interactions Technol. **Page**: p 367-377
Published: Mar 01, 1985
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 11
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
Proposals are now being developed for the construction of high-power photovoltaic systems for operation in low Earth orbit, where the plasma number density is about 1,000 to 1,000,000 per cubic cm. Existing data indicate that interactions between the plasma and high-voltage surfaces of an orbiting power system will occur. In ground tests, where the applied voltage is increased negatively from ground, the array current collection shows an approximately linear rise until it terminates in arcing at greater than several hundred volts negative. This arcing may reduce the power generation efficiency and could possibly affect the low-level logic circuits of the spacecraft. Therefore it is important that the arcing phenomenon be well understood. This study is a survey of the behavior of different **dielectric**-conductor samples, including a solar cell module, that were biased negatively in a low-density plasma environment with the intent of defining arc discharge conditions and characteristics. Procedures and results are discussed.
Major Subject Terms:
ARC DISCHARGES DIELECTRICS ELECTRIC CONDUCTORS SOLAR CELLS SPACE PLASMAS
Minor Subject Terms:
HIGH VOLTAGES LOGIC CIRCUITS LOW EARTH ORBITS MODULES PLASMA DENSITY SAMPLES
Language Note: English
Notes:
In its Spacecraft Environ. Interactions Technol. p 367-377 (SEE N85-22470 13-18)

TITLE: ***Design guidelines for assessing and controlling spacecraft charging effects***

Document ID: **19850014189** N (85N22500) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Purvis, C. K. (NASA Lewis Research Center) Garrett, H. B. (JPL) Whittlesey, A. (JPL) Stevens, N. J. (Hughes Aircraft Co.)
Journal Title: Spacecraft Environ. Interactions Technol. **Page**: p 389
Published: Mar 01, 1985
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 1
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The need for uniform criteria, or guidelines, to be used in all phases of spacecraft design is discussed. Guidelines were developed for the control of absolute and differential charging of spacecraft surfaces by the lower energy space charged particle environment. Interior charging due to higher energy particles is not considered. A guide to good design practices for assessing and controlling charging effects is presented. Uniform design practices for all space vehicles are outlined.
Major Subject Terms:
ELECTROMAGNETIC COMPATIBILITY ELECTROMAGNETIC PULSES GEOSYNCHRONOUS ORBITS SPACECRAFT CHARGING SPACECRAFT DESIGN
Minor Subject Terms:
DESIGN ANALYSIS EXTERNAL SURFACE CURRENTS SPACECRAFT ORBITS STANDARDS
Language Note: English
Notes:
In its Spacecraft Environ. Interactions Technol. p 389 (SEE N85-22470 13-18)

TITLE: ***Galileo internal electrostatic discharge program***

Document ID: **19850014193** N (85N22504) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:

Leung, P. L. (Jet Propulsion Lab., California Inst. of Tech.) Plamp, G. H. (Jet Propulsion Lab., California Inst. of Tech.) Robinson, P. A., Jr. (Jet Propulsion Lab., California Inst. of Tech.)

Journal Title: NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 **Page**: p 423-433
Published: Mar 01, 1985
Corporate Source:

Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)

Pages: 13
Contract Number: None
NASA Subject Category: LAUNCH VEHICLES AND SPACE VEHICLES
Abstract:

The Galileo spacecraft which will orbit Jupiter in 1988 will encounter a very harsh environment of energetic electrons. These electrons will have sufficient energy to penetrate the spacecraft shielding, consequently depositing charges in the dielectric insulating materials or ungrounded conductors. The resulting electric field could exceed the breakdown strength of the insulating materials, producing discharges. The transients produced from these Internal Electrostatic Discharges (IESD) could, depending on their relative location, be coupled to nearby cables and circuits. These transients could change the state of logic circuits or degrade or even damage spacecraft components, consequently disrupting the operation of subsystems and systems of the Galileo spacecraft during its expected mission life. An extensive testing program was initiated for the purpose of understanding the potential threats associated with these IESD events. Data obtained from these tests were used to define design guidelines.

Major Subject Terms:

ELECTRIC DISCHARGES • ELECTRIC FIELDS • ELECTRICAL FAULTS • ELECTRONS • ELECTROSTATIC CHARGE • GALILEO SPACECRAFT

Minor Subject Terms:

DESIGN ANALYSIS • JUPITER (PLANET) • LOGIC CIRCUITS • PERFORMANCE TESTS

Language Note: English
Notes:

In NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 423-433 (SEE N85-22470 13-18)

TITLE: ***Spacecraft environmental interactions: A joint Air Force and NASA research and technology program***

Document ID: **19850014206** N (85N22517) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:

Pike, C. P. (AFGL) Purvis, C. K. (NASA Lewis Research Center) Hudson, W. R. (NASA Washington)

Journal Title: Spacecraft Environ. Interactions Technol., 1983 **Page**: p 599-608
Published: Mar 01, 1985

Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 10
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

A joint Air Force/NASA comprehensive research and technology program on spacecraft environmental interactions to develop technology to control interactions between large spacecraft systems and the charged-particle environment of space is described. This technology will support NASA/Department of Defense operations of the shuttle/IUS, shuttle/Centaur, and the force application and surveillance and detection missions, planning for transatmospheric vehicles and the NASA space station, and the AFSC military space system technology model. The program consists of combined contractual and in-house efforts aimed at understanding spacecraft environmental interaction phenomena and relating results of ground-based tests to space conditions. A concerted effort is being made to identify project-related environmental interactions of concern. The basic properties of materials are being investigated to develop or modify the materials as needed. A group simulation investigation is evaluating basic plasma interaction phenomena to provide inputs to the analytical modeling investigation. Systems performance is being evaluated by both groundbased tests and analysis.

Major Subject Terms:

CHARGED PARTICLES GROUND TESTS LARGE SPACE STRUCTURES PLASMA INTERACTIONS SPACECRAFT CHARGING SPECIFICATIONS

Minor Subject Terms:

ENVIRONMENT EFFECTS MILITARY OPERATIONS SIMULATION SPACE SHUTTLES SPACECRAFT ENVIRONMENTS

Language Note: English
Notes:

In its Spacecraft Environ. Interactions Technol., 1983 p 599-608 (SEE N85-22470 13-18)

TITLE: ***Interactions measurement payload for Shuttle***

Document ID: **19850014207** N (85N22518) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:
Guidice, D. A. (Air Force Geophysics Lab.) Pike, C. P. (Air Force Geophysics Lab.)
Journal Title: NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 **Page**: p 609-618
Published: Mar 01, 1985
Corporate Source:
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 9
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The Interactions Measurement Payload for Shuttle (IMPS) consisted of engineering experiments to determine the effects of the space environment on projected Air Force space systems. Measurements by IMPS on a polar-orbit Shuttle flight will lead to detailed knowledge of the interaction of the low-altitude polar-auroral environment on materials, equipment and technologies to be used in future large, high-power space systems. The results from the IMPS measurements will provide direct input to MIL-STD design guidelines and test standards that properly account for space-environment effects.
Major Subject Terms:
LARGE SPACE STRUCTURES SPACE SHUTTLE PAYLOADS SPACE SHUTTLES SPACECRAFT CHARGING
Minor Subject Terms:
LOW ALTITUDE MILITARY OPERATIONS SPACECRAFT ENVIRONMENTS
Language Note: English
Notes:
In NASA. Lewis Research Center Spacecraft Environ. Interactions Technol., 1983 p 609-618 (SEE N85-22470 13-18)

TITLE: ***Space test program of high-voltage solar array-space plasma interactions***

Document ID: **19850014208** N (85N22519) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI E03
Authors:
Carruth, M. R., Jr. (NASA Marshall Space Flight Center) Purvis, C. K. (NASA Marshall Space Flight Center)
Journal Title: Spacecraft Environ. Interactions Technol., 1983 **Page**: p 619-635
Published: Mar 01, 1985
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 17
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
Future spacecraft, notably the proposed Space Station, will require power systems much larger than have previously been flown. It is recognized that at higher voltages, and at the relatively high plasma density present at low Earth orbital altitudes, undesirable interactions between the high voltage solar array and the space plasma will occur. Space experiments on high voltage solar array space plasma interactions in low Earth orbit are an absolute requirement for confident design of a higher voltage solar array. Experiments are presently being identified to provide the necessary space data for calibration of ground testing, validation of analytical models, and development of design guidelines required for confident design of high voltage solar arrays in space. A proposed flight experiment program which is designed to obtain the required data is summarized.
Major Subject Terms:
ELECTRIC POTENTIAL PLASMA INTERACTIONS SOLAR ARRAYS SPACE PLASMAS SPACE STATIONS
Minor Subject Terms:
CALIBRATING LOW EARTH ORBITS PLASMA DENSITY POWER EFFICIENCY POWER LOSS RADIATION DAMAGE
Language Note: English
Notes:
In its Spacecraft Environ. Interactions Technol., 1983 p 619-635 (SEE N85-22470 13-18)

TITLE: ***Surface voltage gradient role in high voltage solar array-plasma interaction: Center Director's discretionary fund***

Document ID: **19850025254** N (85N33567) **File Series**: NASA Technical Reports
Report Number: NASA-TM-86516 NAS 1.15:86516
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Carruth, M. R., Jr. (NASA Marshall Space Flight Center)
Published: Jul 01, 1985
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 41
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
A large amount of experimental and analytical effort has been directed toward understanding the plasma sheath growth and discharge phenomena which lead to high voltage solar array-space plasma interactions. An important question which has not been addressed is how the surface voltage gradient on such an array may affect these interactions. The results of this study indicate that under certain conditions, the voltage gradient should be taken into account when evaluating the effect on a solar array operating in a plasma environment.
Major Subject Terms:
ELECTRIC POTENTIAL SOLAR ARRAYS SPACE PLASMAS SPACECRAFT CHARGING
Minor Subject Terms:
CHARGED PARTICLES MAGNETIC FIELDS PLASMA INTERACTIONS PLASMA SHEATHS
Language Note: English

NASA STI Help Desk
E-mail: help@sti.nasa.gov
Phone: 301-621-0390 FAX: 301-621-0134

TITLE: ***Electrodynamic tethers. I - Power generation in LEO. II - Thrust for propulsion & power storage***

Document ID: **19850031129** A (85A13280) **File Series**: Open Literature
Report Number: IAF PAPER 84-440
Sales Agency & Price: Issuing Activity
Authors:
Mccoy, J. E. (NASA Johnson Space Center)
Published: Oct 01, 1984
Corporate Source:
NASA Lyndon B. Johnson Space Center (Houston, TX, United States)
Pages: 16
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The power gain and thrust for plasma engines available by unreeling 10 km of insulated Al wire from a spacecraft are investigated. The wire, unreeling in the vertical, would cut the earth's magnetic field lines, thereby generating 20 kW of power in the wire. A drag loss of 20.4 kJ/sec would reduce the power gain to 18.7 kW, an efficiency of 92 percent. Thicker wires could push the power gain to 1 MW at 95 percent efficiency. Conductive 'balloons' at the ends of the tether would function as ionospheric 'brushes' to complete the circuit. Reversing the IXB force by employing on-board stored power would drive the tether current against the induced voltage, providing a 1 N thrust for 8 kW of energy consumed, which could be supplied by solar panels during the day portion of orbit. The equivalent thrust by conventional stationkeeping means would consume 8000 kg of propellant/yr. Techniques for stabilizing the tether in the presence of variable magnetic fields are discussed.
Major Subject Terms:
ELECTRIC GENERATORS • ELECTRODYNAMICS • ELECTROMAGNETIC PROPULSION • PLASMA ENGINES • TETHERED SATELLITES
Minor Subject Terms:
ELECTRIC ENERGY STORAGE • ELECTRIC WIRE • LOW THRUST PROPULSION • POWER GAIN • PROPULSION SYSTEM PERFORMANCE • SYSTEMS SIMULATION • TETHERLINES
Language Note: English
Notes:
International Astronautical Federation, International Astronautical Congress, 35th, Lausanne, Switzerland, Oct. 7-13, 1984. 16 p.

TITLE: ***Polarization of spacecraft generated plasma clouds***

Document ID: **19850032535** A (85A14686) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Katz, I. Parks, D. E. Cooke, D. L. Lilley, J. R., Jr. (Systems, Science and Software, La Jolla)
Journal Title: Geophysical Research Letters **Volume**: 11 **Page**: 1115
Published: Nov 01, 1984
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 2
Contract Number: F19628-82-C-0081
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Space Shuttle STS-3 flight observations have indicated that dense plasma generation by sources aboard the Orbiter was accompanied by a substantial reduction of the electric potential measured by probes fixed on the spacecraft. In a separate experiment, increased plasma densities were observed to follow the release of neutral gas. It is presently suggested that both observations are consistent with the shielding of the electric field that is associated with the Orbiter's motion across the earth's field from the interior of the spacecraft-generated plasma.
Major Subject Terms:
DENSE PLASMAS PLASMA CLOUDS POLARIZATION (CHARGE SEPARATION) SPACE TRANSPORTATION SYSTEM 3 FLIGHT
Minor Subject Terms:
COLLISIONAL PLASMAS EXPANSION PLASMA DENSITY
Language Note: English
Notes:
Geophysical Research Letters (ISSN 0094-8276), vol. 11, Nov. 1984, p. 1115, 1116.
1116

TITLE: ***Characteristics of arc currents on a negatively biased solar cell array in a plasma***

Document ID: **19850036457** A (85A18608) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Snyder, D. B. (NASA Lewis Research Center)
Journal Title: IEEE Transactions on Nuclear Science **Volume**: NS-31 **Page**: 1584-158
Published: Dec 01, 1984
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 4
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The time dependence of the emitted currents during arcing on solar cell arrays is being studied. The arcs are characterized using three parameters: the voltage change of the array during the arc (i.e., the charge lost), the peak current during the arc, and the time constant describing the arc current. This paper reports the dependence of these characteristics on two array parameters, the interconnect bias voltage and the array capacitance to ground. It was found that the voltage change of the array during an arc is nearly equal to the bias voltage. The array capacitance, on the other hand, influences both the peak current and the decay time constant of the arc. Both of these characteristics increase with increasing capacitance.
Major Subject Terms:
ARC DISCHARGES CAPACITANCE PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS
Minor Subject Terms:
ELECTRIC POTENTIAL PLASMA PHYSICS TIME DEPENDENCE
Language Note: English
Notes:
(IEEE, U.S. Defense Nuclear Agency, U.S. Department of Energy, and NASA, Annual Conference on Nuclear and Space Radiation Effects, 21st, Colorado Springs, CO, July 23-25, 1984) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-31, Dec. 1984, p. 1584-1587. Previously announced in STAR as N84-27824.
Previously announced in STAR as N84-27824

TITLE: ***Circuit transients due to negative bias arcs on a high voltage solar array in low earth orbit***

Document ID: **19850037563** A (85A19714) **File Series**: Open Literature
Report Number: AIAA PAPER 85-0385
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Metz, R. N. (Colby College)
Published: Jan 01, 1985
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 7
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Arcing to negatively biased, exposed solar cell interconnects on solar arrays placed in plasma environments has been well established in laboratory tests and inferred from space data. Such arcing may cause damaging interference with the operation of electrical power systems in spacecraft planned to be driven with high voltage solar arrays. A simple analytical model has been developed to estimate the effects of negative bias arcs on solar array power system performance. Solar cell characteristics, plasma interactions and power system features are modeled approximately by a linear, lumped element transient circuit and the time domain equations are solved. Exact numerical results for solar array common-mode and load voltage transients are calculated for typical conditions. Acceptable load transients are found for a range of arc current amplitudes and time constants.
Major Subject Terms:
ELECTRIC ARCS • LOW EARTH ORBITS • PLASMA INTERACTIONS • POWER SUPPLY CIRCUITS • SOLAR ARRAYS • SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
EARTH ORBITS • ELECTRIC POTENTIAL • FLIGHT TESTS • FLOATING POINT ARITHMETIC • PLASMA JETS • SOLAR CELLS • SURGES
Language Note: English
Notes:
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 23rd, Reno, NV, Jan. 14-17, 1985. 7 p.

TITLE: ***Computer simulation of plasma electron collection by PIX-II***

Document ID: **19850037564** A (85A19715) **File Series**: Open Literature
Report Number: AIAA PAPER 85-0386
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Mandell, M. J. (NASA Lewis Research Center) Katz, I. (NASA Lewis Research Center) Jongeward, G. A. (System Science and Software) Roche, J. C. (NASA Lewis Research Center)
Published: Jan 01, 1985
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Systems Science and Software (San Diego, CA, United States)
Pages: 9
Contract Number: NAS3-23881
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
A wake model was defined for the NASCAP/LEO finite element model for the plasma interaction experiment (PIX-II) launched to study the interaction between high-voltage large solar arrays with the space plasma environment. The cell surface model considers the individual cells, distances between interconnects, and the fraction of surface covered by interconnects. Account is taken of the electrostatic potential around the spacecraft, which travels at 7500 mps, over five times the speed of thermal ions. Ram ions are produced ahead of the array and the wake ion density is described with a geometric shadowing model. The model correctly predicted the currents in high and low bias voltages when compared to orbital data. The panel snapover, however, was projected to occur at 100 V and instead occurred at 300 V, which indicates that the snapover state is bistable. Finally, a low potential was both predicted and measured in the wake.
Major Subject Terms:
COMPUTERIZED SIMULATION PLASMA INTERACTION EXPERIMENT SOLAR ARRAYS SPACE PLASMAS
Minor Subject Terms:
ELECTRIC FIELDS HIGH VOLTAGES SECONDARY EMISSION SPACE ENVIRONMENT SIMULATION SPACECRAFT CHARGING WAKES
Language Note: English
Notes:
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 23rd, Reno, NV, Jan. 14-17, 1985. 9 p.

TITLE: ***Characteristics of arc currents on a negatively biased solar cell array in a plasma***

Document ID: **19850036457** A (85A18608) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Snyder, D. B. (NASA Lewis Research Center)

Journal Title: IEEE Transactions on Nuclear Science **Volume**: NS-31 **Page**: 1584-158
Published: Dec 01, 1984
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 4
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:

The time dependence of the emitted currents during arcing on solar cell arrays is being studied. The arcs are characterized using three parameters: the voltage change of the array during the arc (i.e., the charge lost), the peak current during the arc, and the time constant describing the arc current. This paper reports the dependence of these characteristics on two array parameters, the interconnect bias voltage and the array capacitance to ground. It was found that the voltage change of the array during an arc is nearly equal to the bias voltage. The array capacitance, on the other hand, influences both the peak current and the decay time constant of the arc. Both of these characteristics increase with increasing capacitance.

Major Subject Terms:

ARC DISCHARGES CAPACITANCE PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS

Minor Subject Terms:

ELECTRIC POTENTIAL PLASMA PHYSICS TIME DEPENDENCE

Language Note: English
Notes:

(IEEE, U.S. Defense Nuclear Agency, U.S. Department of Energy, and NASA, Annual Conference on Nuclear and Space Radiation Effects, 21st, Colorado Springs, CO, July 23-25, 1984) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-31, Dec. 1984, p. 1584-1587. Previously announced in STAR as N84-27824.

Previously announced in STAR as N84-27824

TITLE: ***Characteristics of electromagnetic interference generated during discharge of Mylar samples***

Document ID: **19850036458** A (85A18609) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Leung, P. L. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena)
Journal Title: IEEE Transactions on Nuclear Science **Volume**: NS-31 **Page**: 1587-159
Published: Dec 01, 1984
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 4
Contract Number: None
NASA Subject Category: PHYSICS (GENERAL)
Abstract:
This paper discusses the measurements of the electromagnetic interference (EMI) generated during discharges of Mylar samples. The two components of EMI, the conducted emission and the radiated emission, are characterized by the replacement current and the radiated RF spectrum respectively. The measured radiated RF spectra reveal important information on the source of the electromagnetic radiation. The possible sources are the replacement current pulse and the discharged generated plasma. The scaling of the amplitudes of the EMI, as a function of the area of the test sample, is also discussed.
Major Subject Terms:
ELECTROMAGNETIC INTERFERENCE ELECTRON IRRADIATION MYLAR (TRADEMARK) RADIO FREQUENCY DISCHARGE SPACE ENVIRONMENT SIMULATION SPACECRAFT CHARGING
Minor Subject Terms:
PLASMA DENSITY PLASMA JETS RADIATION HARDENING RADIO SPECTRA
Language Note: English
Notes:
(IEEE, U.S. Defense Nuclear Agency, U.S. Department of Energy, and NASA, Annual Conference on Nuclear and Space Radiation Effects, 21st, Colorado Springs, CO, July 23-25, 1984) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-31, Dec. 1984, p. 1587-1590. NASA-supported research.
NASA-supported research

TITLE: ***The effect of plasma on solar cell array arc characteristics***

Document ID: **19850037562** A (85A19713) **File Series**: Open Literature
Report Number: AIAA PAPER 85-0384
Sales Agency & Price: Issuing Activity
Authors:
Snyder, D. B. (NASA Lewis Research Center) Tyree, E. (NASA Lewis Research Center)
Published: Jan 01, 1985
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Case Western Reserve Univ. (Cleveland, OH, United States)
Pages: 10
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The influence from the ambient plasma on the arc characteristics of a negatively biased solar cell array was investigated. The arc characteristics examined were the peak current during an arc, the decay time as the arc terminates, and the charge lost during the arc. These arc characteristics were examined in a nitrogen plasma with charge densities ranging from 15,000 to 45,000 cu cm. Background gas pressures ranged from 8x1,000,000 to 6x100,000 torr. Over these ranges of parameters no significant effect on the arc characteristics were seen. Arc characteristics were also examined for three gas species: helium, nitrogen and argon. The helium arcs have higher peak currents and shorter decay times than nitrogen and argon arcs. There are slight differences in the arc characteristics between nitrogen and argon. These differences may be caused by the differences in mass of the respective species. Also, evidence is presented for an electron emission mechanism appearing as a precursor to solar array arcs. Occasionally the plasma generator could be turned off, and currents could still be detected in the vacuum system. When these currents are presented, arcs may occur.
Major Subject Terms:
PLASMA INTERACTIONS PLASMA JETS SOLAR CELLS
Minor Subject Terms:
ARC DISCHARGES ARGON ELECTRON EMISSION GAS PRESSURE HELIUM NITROGEN PLASMA PLASMA CURRENTS PLASMA DECAY
Language Note: English
Notes:
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 23rd, Reno, NV, Jan. 14-17, 1985. 10 p. Previously announced in STAR as N85-11133.

TITLE: ***When spacecraft get charged up, they have minds of their own***

Document ID: **19850042636** A (85A24787) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Lerner, E. J.
Journal Title: Aerospace America **Volume**: 23 **Page**: 38
Published: Feb 01, 1985
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 4
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The problems and solutions pursued in development of a flight model discharge system (FMDS) for eliminating the arcing that occurs in satellites are described. The charges arise from particle bombardment and the lack of sufficient conductive particles in the space environment. Potentials up to 10 kV build up between insulated conductors and eventually arc discharge and can upset or destroy on-board electronic systems. After detecting the charge build-up the FMDS generates a plasma to conduct the charge to space or the spacecraft exterior. The device carries on on-board template data base for comparisons with normal charging events to permit functional charging events to continue. Difficulties are still being encountered in producing plasma quickly enough to prevent discharges.
Major Subject Terms:
EXTERNAL SURFACE CURRENTS SPACECRAFT CHARGING
Minor Subject Terms:
GEOSYNCHRONOUS ORBITS NEUTRALIZERS PLASMA GENERATORS PROTON ENERGY
Language Note: English
Notes:
Aerospace America (ISSN 0740-722X), vol. 23, Feb. 1985, p. 38, 40, 42, 83.
40, 42, 83

TITLE: ***The high voltage design of a space qualified detector for Space Telescope***

Document ID: **19850043267** A (85A25418) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Fleming, J. C. (Martin Marietta Aerospace) Cooke, C. M. (MIT)
Published: Jan 01, 1984
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 9
Contract Number: None
NASA Subject Category: INSTRUMENTATION AND PHOTOGRAPHY
Abstract:
The Faint Object Spectrograph (FOS) will be employed during the first mission of the Space Telescope. As its name implies, this instrument is designed to produce spectrographic measurements data from extremely faint astronomical objects. The FOS utilizes as detector a digicon offering a linear array of 512 photon-counting channels. Photon-counting sensitivity is achieved by utilizing a very high operating voltage, in this case 22,500 volts. Attention is given to packaged detector requirements, aspects of materials selection, details of high voltage design, high voltage packaging, processing procedures, design validation testing, and surface discharge noise.
Major Subject Terms:
ASTRONOMICAL SPECTROSCOPY ELECTRONIC PACKAGING FAINT OBJECT CAMERA HIGH VOLTAGES HUBBLE SPACE TELESCOPE
Minor Subject Terms:
ENVIRONMENTAL TESTS LINEAR ARRAYS PHOTOSENSITIVITY RADIATION COUNTERS SIGNAL PROCESSING
Language Note: English
Notes:
IN: Instrumentation in astronomy V; Proceedings of the Fifth Meeting, London, England, September 7-9, 1983 (A85-25360 10-89). Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 452-460.
Instrumentation in astronomy V London September 7-9, 1983

TITLE: ***The high voltage design of a space qualified detector for Space Telescope***

Document ID: **19850043267** A (85A25418) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Fleming, J. C. (Martin Marietta Aerospace) Cooke, C. M. (MIT)

Published: Jan 01, 1984
Corporate Source:

(Corporate Source(s) Not Available)

Pages: 9
Contract Number: None
NASA Subject Category: INSTRUMENTATION AND PHOTOGRAPHY
Abstract:

The Faint Object Spectrograph (FOS) will be employed during the first mission of the Space Telescope. As its name implies, this instrument is designed to produce spectrographic measurements data from extremely faint astronomical objects. The FOS utilizes as detector a digicon offering a linear array of 512 photon-counting channels. Photon-counting sensitivity is achieved by utilizing a very high operating voltage, in this case 22,500 volts. Attention is given to packaged detector requirements, aspects of materials selection, details of high voltage design, high voltage packaging, processing procedures, design validation testing, and surface discharge noise.

Major Subject Terms:

ASTRONOMICAL SPECTROSCOPY ELECTRONIC PACKAGING FAINT OBJECT CAMERA HIGH VOLTAGES HUBBLE SPACE TELESCOPE

Minor Subject Terms:

ENVIRONMENTAL TESTS LINEAR ARRAYS PHOTOSENSITIVITY RADIATION COUNTERS SIGNAL PROCESSING

Language Note: English
Notes:

IN: Instrumentation in astronomy V; Proceedings of the Fifth Meeting, London, England, September 7-9, 1983 (A85-25360 10-89). Bellingham, WA, SPIE - The International Society for Optical Engineering, 1984, p. 452-460.

Instrumentation in astronomy V London September 7-9, 1983

TITLE: ***Simulation of external and internal electrostatic discharges at the spacecraft system test level***

Document ID: **19850056106** A (85A38257) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:

Whittlesey, A. (Jet Propulsion Lab., California Inst. of Tech.) Leung, P. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena)

Published: Jan 01, 1984
Corporate Source:

Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)

Pages: 5
Contract Number: None
NASA Subject Category: GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)
Abstract:

Environmental test activities concerned with space plasma-caused charging and discharing phenomena are discussed. It is pointed out that the origin of such an electrostatic discharge (ESD) is charging of spacecraft dielectrics by an energetic plasma in geosynchronous orbit, Jupiter's magnetosphere, or other similar space environments. In dealing with environmental testing problems, it is necessary to define the location and magnitude of any ESD's in preparation for a subsequent simulation of the given conditions. Questions of external and internal charging are discussed separately. The environmental hazard from an external discharge can be assessed by viewing the dielectric surface as one side of a parallel plate capacitor. In the case of internal charging, the level of environmental concern depends on the higher energy spectrum of the ambient electrons.

Major Subject Terms:

ELECTROSTATIC CHARGE GROUND TESTS SPACECRAFT CHARGING

Minor Subject Terms:

DIELECTRICS ENVIRONMENTAL TESTS GALILEO SPACECRAFT SPACE PLASMAS

Language Note: English
Notes:

IN: Aerospace Testing Seminar, 8th, Los Angeles, CA, March 21-23, 1984, Proceedings (A85-38251 17-14). Mount Prospect, IL, Institute of Environmental Sciences, 1984, p. 43-47. NASA-supported research.

Aerospace Testing Seminar Los Angeles, CA March 21-23, 1984

TITLE: ***Calculation of threshold conditions for materials charging in Maxwellian plasmas***

Document ID: **19860003671** N (86N13139) **File Series**: NASA Technical Reports
Report Number: AD-A157123 AFGL-TR-85-0020 AFGL-ERP-907
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:

Rubin, A. G. (Air Force Geophysics Lab.) Tautz, M. (Air Force Geophysics Lab.)

Published: Jan 25, 1985

Corporate Source:

Air Force Geophysics Lab. (Hanscom AFB, MA, United States)

Pages: 18
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:

Space Plasmas at geosynchronous orbit are usually not characterized by a single Maxwellian distribution function. Plasmas are characterized as single Maxwellians to first order and as a sum of two Maxwellians as a better approximation. A threshold electron temperature condition for charging of materials in the single Maxwellian is derived. Conditions for materials charging in the dual Maxwellian case are derived and illustrated. These are threefold: an initial negative current; a threshold electron temperature and a threshold electron current.

Major Subject Terms:

GEOSYNCHRONOUS ORBITS MAXWELL EQUATION ORBIT CALCULATION PLASMAS (PHYSICS)

Minor Subject Terms:

COMPUTATION CONDITIONS DISTRIBUTION FUNCTIONS ELECTRONS PLASMA TEMPERATURE SATELLITE ORBITS SPACECRAFT ORBITS SUN SYNCHRONOUS SATELLITES THRESHOLD CURRENTS

Language Note: English

TITLE: ***Development of the VOLT-A shuttle experiment***

Document ID: **19860004641** N (86N14110) **File Series**: NASA Technical Reports
Report Number: NASA-TM-87169 E-2807 NAS 1.15:87169
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Bifano, W. J. (NASA Lewis Research Center) Bozek, J. M. (NASA Lewis Research Center) Ferguson, D. C. (NASA Lewis Research Center)
Published: Jan 01, 1985
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 13
Contract Number: None
NASA Subject Category: SPACE SCIENCES (GENERAL)
Abstract:
The NASA Lewis Research Center (LeRC) is investigating potential problems associated with the operation of high voltage solar cell arrays in the space plasma environment. At high voltages, interactions between the solar array and the space plasma could result in unacceptable levels of electrical discharge (arcing) and/or parasitic losses (current drains from the array to the plasma). The objective of the Voltage Operating Limit Tests (VOLT-A) Shuttle bay experiment is to characterize space plasma/solar cell panel interactions in low earth orbit. VOLT-A consists of an experiment plate subassembly which contains four solar panels, an electronics subassembly and a Langmuir probe subassembly mounted on an MPESS carrier. During a given 8.25 hour data taking period (5-1/2 continuous orbits), the solar panels, which represent state-of-the-art solar cell technologies, will be sequentially subjected to bias voltages in steps ranging from minus 626 V to plus 313 V. Appropriate measurements will be made at each voltage to characterize arcing and parasitic losses. Corresponding measurements of the plasma environment (plasma density, electron temperature and neutral density) will also be made. Data will be recorded on an on-board tape recorder for subsequent data reduction and analysis.
Major Subject Terms:
EARTH ORBITS HIGH VOLTAGES LOSSES SOLAR CELLS SPACE PLASMAS
Minor Subject Terms:
AEROSPACE ENVIRONMENTS ARC DISCHARGES ELECTRIC ARCS ELECTRIC POTENTIAL LOW EARTH ORBITS SPACEBORNE EXPERIMENTS
Language Note: English
Notes:
Presented at the 18th Photovoltaic Specialists Conference, Las Vegas, Nev., 21-25 Oct. 1985; sponsored by IEEE
Photovoltaic Specialists Conference Las Vegas, NV 21-25 Oct. 1985

TITLE: ***Characterization of EMI generated by the discharge of a VOLT solar array***

Document ID: **19860010269** N (86N19740) **File Series**: NASA Technical Reports
Report Number: NASA-CR-176537 JPL-PUB-85-82 NAS 1.26:176537
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Leung, P. (Jet Propulsion Lab., California Inst. of Tech.)
Published: Nov 01, 1985
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 24
Contract Number: NAS7-918
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The interaction of a high-voltage solar array with the space plasma environment is investigated in a laboratory simulation experiment. Discharges are observed to occur when the solar array is at a sufficiently high negative bias with respect to the plasma. The frequency of occurrence of discharge is found to depend critically on the plasma density and on the geometry of the array. The electromagnetic interference (EMI) associated with a discharge is also measured. The amplitude of EMI increases with the magnitude of the high voltage. Since the discharge-generated EMI is of significant amplitude, its effect on the performance of systems in space must be evaluated.
Major Subject Terms:
HIGH VOLTAGES PLASMA INTERACTIONS SOLAR ARRAYS SPACE PLASMAS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
ELECTRIC DISCHARGES ELECTROMAGNETIC INTERFERENCE LABORATORIES SIMULATION
Language Note: English

TITLE: ***Ionization induced instability in an electron collecting sheath***

Document ID: **19860017066** N (86N26538) **File Series**: NASA Technical Reports
Report Number: AD-A165330 SSS-R-85-7343 AFGL-TR-85-0256 SR-2
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Cooke, D. L. (Systems Science and Software) Katz, I. (Systems Science and Software)
Published: Jun 01, 1985
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 30
Contract Number: F19628-82-C-0081
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:
A numerical investigation of the electron collecting sheath about a positively biased probe in the ionosphere has been conducted to determine the effect of ionization within the sheath. This report is directed at the space charge limited regime appropriate to objects with characteristic size much larger than the ambient Debye length, and uniform surface potential much greater than the ambient plasma temperature. A fluid approximation is employed to model the dynamics of the secondary plasma produced within the sheath. The results indicate that when the secondary ion production exceeds a critical level, the sheath edge propagates outward in an explosive fashion, in a manner similar to the propagation of double layers. This critical level is shown to be equivalent to a mean free path for ionization by electrons lambda sub ie < (sq. rt. (m(sub i)/m(sub e))) (D(sub S)/alpha) where D sub S is the sheath thickness and alpha is a geometry dependent parameter. Usual ionosphere-probe interactions appear to be sub critical, but an enhanced neutral background might be produced by shuttle contaminants, could reach the critical level, and trigger the instability.
Major Subject Terms:
ACCEPTOR MATERIALS AURORAL IONIZATION BIAS ELECTROMAGNETIC PROPERTIES ELECTRONS ION PROBES IONIZATION IONOSPHERIC TEMPERATURE MEAN FREE PATH PLASMA LAYERS PLASMA PROBES PLASMA SHEATHS PLASMAS (PHYSICS) SPACE CHARGE TEMPERATURE PROBES
Minor Subject Terms:
COLLECTION COMPUTER PROGRAMS NUMERICAL ANALYSIS SPACE SHUTTLES SPACECRAFT COMPONENTS STABILITY
Language Note: English

TITLE: ***Electrodynamic tether technology considerations***

Document ID: **19860018185** N (86N27657) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI A03
Authors:
Kolecki, J. C. (NASA Lewis Research Center)
Journal Title: NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2
Page: p 383-386
Published: Jun 01, 1986
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 4
Contract Number: None
NASA Subject Category: MECHANICAL ENGINEERING
Abstract:
The electrodynamic tether operation was studied. Plasma contactors, power management and conditioning, and exposure of materials were considered. Multikilowatt electrodynamic tether systems need a variety of supporting technologies in order to be viable. The area of interface between the high voltage end of the electrodynamic tether and the user was not addressed, however, it must be in order for the successful and safe operation of the system.
Major Subject Terms:
AERODYNAMIC DRAG ELECTRODYNAMICS ELECTROMAGNETIC INTERACTIONS PLASMA CURRENTS TETHERLINES
Minor Subject Terms:
ELECTRON GUNS HOLLOW CATHODES POWER CONDITIONING SPACE COMMERCIALIZATION
Language Note: English
Notes:
In NASA, Washington Applications of Tethers in Space: Workshop Proceedings, Vol. 2 p 383-386 (SEE N86-27644 18-37)

TITLE: ***The voltage threshold for arcing for solar cells in LEO: Flight and ground test results***

Document ID: **19860018653** N (86N28125) **File Series**: NASA Technical Reports
Report Number: NASA-TM-87259 • E-2951 • NAS 1.15:87259 • AIAA PAPER 86-0362
Sales Agency & Price: CASI Hardcopy A03 • CASI Microfiche A01
Authors:
Ferguson, D. C. (NASA Lewis Research Center)
Published: Mar 01, 1986
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 22
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Ground and flight results of solar cell arcing in low Earth orbit (LEO) conditions are compared and interpreted. It is shown that an apparent voltage threshold for arcing may be produced by a strong power law dependence of arc rate on voltage, combined with a limited observation time. The change in this apparent threshold with plasma density is a reflection of the density dependence of the arc rate. A nearly linear dependence of arc rate on density is inferred from the data. A real voltage threshold for arcing for 2 by 2 cm solar cells may exist however, independent of plasma density, near -230 V relative to the plasma. Here, arc rates may change by more than an order of magnitude for a change of only 30 V in array potential. For 5.9 by 5.9 solar cells, the voltage dependence of the arc rate is steeper, and the data are insufficient to indicate the existence of an arcing increased by an atomic oxygen plasma, as is found in LEO, and by arcing from the backs of welded-through substrates.
Major Subject Terms:
EARTH ORBITS • ELECTRIC ARCS • FLIGHT TESTS • PLASMA DENSITY • SOLAR CELLS • STRUCTURAL DESIGN
Minor Subject Terms:
ELECTRIC POTENTIAL • ELECTRON ENERGY • ELECTRON TUNNELING • ELECTROSTATIC PROBES • LOW EARTH ORBITS
Language Note: English
Notes:
Presented at the 24th AIAA Aerospace Sciences Meeting, Reno, Nev., 6-9 Jan. 1986
AIAA Aerospace Sciences Meeting Reno, NV 6-9 Jan. 1986

TITLE: ***The roles of VxB and density gradients in plasma electric fields measured from the shuttle Orbiter***

Document ID: **19860020201** N (86N29673) **File Series**: NASA Technical Reports
Report Number: AD-A165230 • SSS-R-85-7339 • AFGL-TR-85-0257 • SR-3
Sales Agency & Price: CASI Hardcopy A03 • CASI Microfiche A01
Authors:
Lilley, J. R., Jr. (Systems Science and Software) • Katz, I. (Systems Science and Software) • Cooke, D. L. (Systems Science and Software)
Published: Jun 01, 1985
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 14
Contract Number: F19628-82-C-0081
NASA Subject Category: PLASMA PHYSICS
Abstract:
Plasma electric fields due to motion through the geomagnetic field and to density gradients are of the same order of magnitude in the wake of shuttle sized objects. Density gradient fields dominate in the wakes of smaller satellites while vxB fields dominate behind larger structures. Supporting experimental data is cited. Computational results (calculated using the spacecraft charging code POLAR) which demonstrate the roles of the two fields in the wake are also presented.
Major Subject Terms:
AURORAS • EARTH IONOSPHERE • ELECTRIC CHARGE • ELECTRIC FIELDS • GRADIENTS • MAGNETIC CHARGE DENSITY • PLASMA DENSITY • SPACE CHARGE • SPACE SHUTTLE ORBITERS • WAKES
Minor Subject Terms:
ARTIFICIAL SATELLITES • COMPUTER PROGRAMS • PLASMAS (PHYSICS)
Language Note: English

TITLE: ***High voltage solar array for MPD propulsion system***

Document ID: **19860026261** A (86A10999) **File Series**: Open Literature
Report Number: AIAA PAPER 85-2047
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Ijichi, K. Gohnai, T. Gotoh, M. (Mitsubishi Electric Corp.) Fujii, H. (Mitsubishi Electric Corp.) Kuriki, K. (Tokyo, University)
Published: Sep 01, 1985
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 8
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Series-parallel switching of solar arrays has been demonstrated to provide high voltage power to charge capacitors using ground use solar arrays. To prevent arcing on solar arrays, conductive coating of solar cell cover glass is proposed based on the analysis of space plasma interactions. The arrangement of solar array modules to supply high voltage is studied, and it is found that at least twice as much voltage difference as that of an array module is unavoidable between solar array modules, and they should be taken into the design. The concept of high power bus system is proposed as an application of this high voltage solar array system.
Major Subject Terms:
MAGNETOPLASMADYNAMICS PLASMA PROPULSION SOLAR ARRAYS SPACE PLATFORMS SWITCHING
Minor Subject Terms:
BLOCK DIAGRAMS VOLT-AMPERE CHARACTERISTICS WEIGHT REDUCTION
Language Note: English
Notes:
AIAA, DGLR, and JSASS, International Electric Propulsion Conference, 18th, Alexandria, VA, Sept. 30-Oct. 2, 1985. 8 p.

TITLE: ***Ionization induced instability in an electron collecting sheath***

Document ID: **19860032863** A (86A17601) **File Series**: Open Literature
Report Number: AIAA PAPER 85-6059
Sales Agency & Price: Issuing Activity
Authors:
Cooke, D. L. Katz, I. (S-Cubed)
Published: Nov 01, 1985
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 29
Contract Number: F19628-82-C-0081
NASA Subject Category: PLASMA PHYSICS
Abstract:
A numerical investigation of the electron collecting sheath about a positively biased probe in the ionosphere has been conducted to determine the effect of ionization within the sheath. This study is directed at the space charge limited regime appropriate to objects with characteristic size much larger than the ambient Debye length, and uniform surface potential much greater than the ambient plasma temperature. A fluid approximation is employed to model the dynamics of the secondary plasma produced within the sheath. The results indicate that when the secondary ion production exceeds a critical level, the sheath edge propagates outward in an explosive fashion, in a manner similar to the propagation of double layers. This critical layer is shown to be equivalent to a mean free path for ionization by electrons. Usual ionosphere-probe interactions appear to be sub-critical, but an enhanced neutral background as might be produced by shuttle contaminants could reach the critical level and trigger the instability.
Major Subject Terms:
GAS IONIZATION IONOSPHERIC SOUNDING PLASMA PROBES PLASMA SHEATHS SPACE CHARGE
Minor Subject Terms:
ION PRODUCTION RATES PLASMA DENSITY PLASMA DYNAMICS PLASMA POTENTIALS
Language Note: English
Notes:
AIAA, Shuttle Environment and Operations Conference, 2nd, Houston, TX, Nov. 13-15, 1985. 29 p.

NASA STI Help Desk
E-mail: help@sti.nasa.gov
Phone: 301-621-0390 FAX: 301-621-0134

TITLE: ***Electric propulsion produced environments and possible interactions with the SP-100 power system***

Document ID: **19860033101** A (86A17839) **File Series**: Open Literature
Report Number: AIAA PAPER 85-2046
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Deininger, W. D. (California Institute of Technology)
Published: Sep 01, 1985
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 16
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
An examination of a conceptual SP-100 type power system has been conducted to assess the effect of possible electric thruster induced contamination. The operating characteristics and known exhaust plume properties of various electric thrusters are summarized along with the natural environment and its effects to provide background for the contamination discussion. Charge buildup on nonconducting surfaces, differential charging of surfaces and arcing should be moderated by the operation of an electric thruster system. Thin film deposition of eroded thruster materials is a possible contamination mechanism. Electric thruster field efflux and propellant condensation should have only a minor contaminating effect upon a nuclear power system.
Major Subject Terms:
ELECTRIC PROPULSION • LOW THRUST PROPULSION • NUCLEAR ELECTRIC PROPULSION • SPACECRAFT CONTAMINATION • SPACECRAFT POWER SUPPLIES • SPACECRAFT PROPULSION
Minor Subject Terms:
CHARGED PARTICLES • IONIZATION • PLASMA INTERACTIONS • PLUMES • SPACE POWER REACTORS • THIN FILMS • THRUSTORS
Language Note: English
Notes:
AIAA, JSASS, and DGLR, International Electric Propulsion Conference, 18th, Alexandria, VA, Sept. 30-Oct. 2, 1985. 16 p.

TITLE: ***Threshold determining mechanisms for discharges in high voltage solar arrays***

Document ID: **19860035096** A (86A19834) **File Series**: Open Literature
Report Number: AIAA PAPER 86-0364
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Parks, D. E. (Systems Science and Software) Jongeward, G. A. (Systems Science and Software) Katz, I. (Systems Science and Software) Davis, V. A. (Systems Science and Software)

Published: Jan 01, 1986
Corporate Source:

Systems Science and Software (La Jolla, CA, United States)

Pages: 7
Contract Number: NAS3-23881
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

A theory is developed to account for the observed properties of discharges of solar arrays immersed in plasma. The theory is based on the assumption that a thin layer of insulating contaminant covers any metallic surface exposed to the plasma. Quantities derivable from the theory include a voltage threshold for arcing. The existence of the threshold and its predicted weak dependence on plasma density appear consistent with experimental results.

Major Subject Terms:

ARC DISCHARGES ELECTRIC ARCS ELECTRON PLASMA PLASMA DENSITY SOLAR ARRAYS THRESHOLD VOLTAGE

Minor Subject Terms:

CONDUCTION BANDS ELECTRON EMISSION ELECTRON ENERGY INSULATORS METAL SURFACES

Language Note: English
Notes:

AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 7 p.

NASA STI Help Desk
E-mail: help@sti.nasa.gov
Phone: 301-621-0390 FAX: 301-621-0134

TITLE: ***Circuit transients due to negative bias arcs-II***

Document ID: **19860035097** A (86A19835) **File Series**: Open Literature
Report Number: AIAA PAPER 86-0366
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Metz, R. N. (Colby College)
Published: Jan 01, 1986
Corporate Source:
Colby Coll. (Waterville, ME, United States)
Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Two new models of negative-bias arcing on a solar cell power system in Low Earth Orbit are presented. One is an extended, analytical model and the other is a non-linear, numerical model. The models are based on an earlier analytical model in which the interactions between solar cell interconnects and the space plasma as well as the parameters of the power circuit are approximated linearly. Transient voltages due to arcs struck at the negative thermal of the solar panel are calculated in the time domain. The new models treat, respectively, further linear effects within the solar panel load circuit and non-linear effects associated with the plasma interactions. Results of computer calculations with the models show common-mode voltage transients of the electrically floating solar panel struck by an arc comparable to the early model but load transients that differ substantially from the early model. In particular, load transients of the non-linear model can be more than twice as great as those of the early model and more than twenty times as great as the extended, linear model.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRIC ARCS NEGATIVE CONDUCTANCE NETWORK ANALYSIS SOLAR ARRAYS SOLAR CELLS
Minor Subject Terms:
COMPUTERIZED SIMULATION EQUIVALENT CIRCUITS LOW EARTH ORBITS PLASMA INTERACTIONS SURGES
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 6 p.

TITLE: ***On plasma disturbances caused by the motion of the Space Shuttle and small satellites - A comparison of in situ observations***

Document ID: **19860037062 A** (86A21800) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Samir, U. (Michigan, University) **Stone**, N. H. (NASA Marshall Space Flight Center) Wright, K. H., Jr. (Alabama, University)
Journal Title: Journal of Geophysical Research **Volume**: 91 **Page**: 277-285
Published: Jan 01, 1986
Corporate Source:
Michigan Univ. (Ann Arbor, MI, United States)
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Alabama Univ. (Huntsville, AL, United States)
Pages: 9
Contract Number: NAS8-33982
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Recent results regarding the interactions between a body and its environmental space **plasma**, made by charged particle probes mounted in the bay of the Space Shuttle Orbiter Columbia (STS 3 mission), are compared with earlier results, obtained from small ionospheric satellites, in an attempt to widen our scope of knowledge and understanding regarding such interactions. The objective is to work toward a unified model of body-space **plasma** interactions in the solar system covering a variety of **plasma** and body conditions. The comparisons focus mainly on (1) the (wake/ram) current ratio; (2) the generation of charged particle density fluctuations (indicative of **plasma** turbulence) around the body; and (3) the increase in electron temperature ahead and in the wake of the satellite. The main results of the comparison are that (1) the (wake/ram) current ratio (or current depletion in the wake) for the Orbiter is 1 to 2 orders of magnitude larger than the ratio for small ionospheric satellites; and (2) fluctuations in density (or turbulence) are observed for both 'large body' (Shuttle Orbiter) and 'smaller body' (standard ionospheric satellites). However, the cause of the turbulence may not be the same for both cases; (3) the results for the electronic temperature enhancement due to the Shuttle Orbiter are in contrast with measurements from smaller ionospheric satellites. A path to follow in future Shuttle experiments is suggested and caution that care be taken in interpreting local particle and field measurements.
Major Subject Terms:
IONOSPHERIC DISTURBANCES **PLASMA** TURBULENCE **PLASMA**-PARTICLE INTERACTIONS SPACE PLASMAS SPACE SHUTTLES
Minor Subject Terms:
CHARGED PARTICLES ELECTRON ENERGY IONOSPHERIC SOUNDING SPACE TRANSPORTATION SYSTEM 3 FLIGHT SPACECRAFT MOTION
Language Note: English
Notes:
Journal of Geophysical Research (ISSN 0148-0227), vol. 91, Jan. 1, 1986, p. 277-285.

TITLE: ***Energy broadening due to space-charge oscillations in high current electron beams***

Document ID: **19860038152** A (86A22890) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Katz, I. (Systems Science and Software) Jongeward, G. A. (Systems Science and Software) Parks, D. E. (Systems Science and Software) Reasoner, D. L. (NASA Marshall Space Flight Center) Purvis, C. K. (NASA Lewis Research Center)
Journal Title: Geophysical Research Letters **Volume**: 13 **Page**: 64-67
Published: Jan 01, 1986
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
NASA Marshall Space Flight Center (Huntsville, AL, United States)
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 4
Contract Number: F19628-82-C-0081 NAS3-23881
NASA Subject Category: NUCLEAR AND HIGH-ENERGY PHYSICS
Abstract:
During electron beam accelerator operation on Spacelab I, substantial fluxes of electrons were observed with energies greater than the initial beam energy. Numerical calculations are performed for the emission of an unneutralized, one-dimensional electron beam. These calculations show clearly that space charge oscillations, which are associated with the charge buildup on the emitter, strongly modify the beam and cause the returning beam particles to have a distribution of kinetic energies ranging from half to over twice the initial energy.
Major Subject Terms:
ELECTRON ACCELERATION ELECTRON BEAMS ELECTRON EMISSION SPACE CHARGE
Minor Subject Terms:
ELECTRON GUNS EQUATIONS OF MOTION SEPAC (PAYLOAD)
Language Note: English
Notes:
Geophysical Research Letters (ISSN 0094-8276), vol. 13, Jan. 1986, p. 64-67.

TITLE: ***Charging of a manned maneuvering unit in the Shuttle wake***

Document ID: **19860039310** A (86A24048) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Rubin, A. G. Besse, A. (USAF, Geophysics Laboratory, Bedford)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 23 **Page**: 122-124
Published: Feb 01, 1986
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 3
Contract Number: None
NASA Subject Category: SPACE TRANSPORTATION
Abstract:
The problem of Space Shuttle Manned Maneuvering Unit (MMU) charging by auroral electronic streams is addressed by a simple model that considers the question of how high the MMU potential can become before the innermost ion of the Mach cone deviates enough to be collected. This threshold provides a lower bound to the negative charging potential, assuming that the aurora is sufficiently energetic to charge in the absence of ions.
Major Subject Terms:
AURORAS MANNED MANEUVERING UNITS SPACE SHUTTLE ORBITERS SPACECRAFT CHARGING WAKES
Minor Subject Terms:
CURRENT DENSITY OXYGEN IONS THRESHOLD CURRENTS
Language Note: English
Notes:
Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Jan.-Feb. 1986, p. 122-124.

TITLE: ***The role of unneutralized surface ions in negative potential arcing***

Document ID: **19860040787** A (86A25525) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Jongeward, G. A. (Systems Science and Software) Katz, I. (Systems Science and Software) Mandell, M. J. (Systems Science and Software) Parks, D. E. (Systems Science and Software)
Journal Title: IEEE Transactions on Nuclear Science **Volume**: NS-32 **Page**: 4087-409
Published: Dec 01, 1985
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 5
Contract Number: NAS3-23881
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:
The observed arcing on negatively biased solar arrays exposed to plasma environments is shown to be due to an effective charge layer on the interconnect formed by ion collection from the plasma. Time scales to form this layer are shown to be in agreement with experimental observations. A quantitative theory is presented which predicts arcing threshold dependence on plasma density and external potentials. After breakdown, the discharge process is modeled as space charge limited transport to nearby coverslips. Peak currents and decay times predicted by this model are compared with experimental observations.
Major Subject Terms:
ELECTRIC DISCHARGES ELECTRIC POTENTIAL ION SHEATHS PLASMA INTERACTIONS SOLAR ARRAYS SPACE STATIONS
Minor Subject Terms:
ELECTRIC ARCS ELECTRIC FIELDS EQUIVALENT CIRCUITS SURFACE IONIZATION THRESHOLD VOLTAGE
Language Note: English
Notes:
(IEEE, DNA, Sandia National Laboratories, and NASA, 1985 Annual Conference on Nuclear and Space Radiation Effects, 22nd, Monterey, CA, July 22-24, 1985) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-32, Dec. 1985, p. 4087-4091.

TITLE: ***Further observations of Space Shuttle plasma-electrodynamic effects from OSS-1/STS-3***

Document ID: **19860047269** A (86A32007) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Stone, N. H. (NASA Marshall Space Flight Center) Hwang, K. S. (NASA Marshall Space Flight Center) Wright, K. H., Jr. (Alabama, University) Samir, U. (Tel Aviv University) Murphy, G. B. (Iowa, University) Shawhan, S. D. (NASA Washington, DC)
Journal Title: Geophysical Research Letters **Volume**: 13 **Page**: 217-220
Published: Mar 01, 1986
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Alabama Univ. (Huntsville, AL, United States)
Tel-Aviv Univ. (Ramat-Aviv, Tel-Aviv, Israel)
Michigan Univ. (Ann Arbor, MI, United States)
Iowa Univ. (Iowa City, IA, United States)
NASA (Washington, DC, United States)
Pages: 4
Contract Number: NAS8-33982
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Recent analyses of ion measurements obtained from the Differential Ion Flux Probe (DIFP) on the deployed Plasma Diagnostics Package (PDP) during the OSS-1/STS-3 mission have provided an additional insight into the plasma-electrodynamics of the Space Shuttle Orbiter: (1) Measured ion flow directions and energies suggest that the disturbance created in the ionospheric plasma by the Shuttle Orbiter may be confined to an interaction region that extends on the order of 10 m in the forward direction and has a boundary thickness of about 2 m. (2) A correlation between the DIFP and pressure gauge measurements indicates a direct, local proportionality between the neutral gas and ion densities. (3) Preliminary results from a theoretical model of the possible interaction between measured secondary, high inclination ion streams and the ambient plasma indicate the generation of broad-band electrostatic noise such as that observed by wave instruments on the PDP.
Major Subject Terms:
AEROSPACE ENVIRONMENTS ELECTRODYNAMICS PLASMA DIAGNOSTICS PLASMA-ELECTROMAGNETIC INTERACTION SPACEBORNE EXPERIMENTS
Minor Subject Terms:
ION TEMPERATURE IONOSPHERIC ION DENSITY NEUTRAL GASES OSS-1 PAYLOAD PARTICLE FLUX DENSITY SPACE SHUTTLE ORBITERS SPACE TRANSPORTATION SYSTEM 3 FLIGHT
Language Note: English
Notes:
Geophysical Research Letters (ISSN 0094-8276), vol. 13, March 1986, p. 217-220.

TITLE: ***Anomalous current collection and arcing of solar-cell modules in a simulated high-density low-earth-orbit plasma***

Document ID: **19860059708** A (86A44446) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Thiemann, H. (Physikalisch-Technische Studien GmbH) Bogus, K. (ESA)
Journal Title: ESA Journal **Volume**: 10 **Issue**: 1, 19
Published: Jan 01, 1986
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 15
Contract Number: ESA-5929/83-NL/PB
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Based on the evaluation of previous studies, the interaction of elevated-voltage solar arrays with the surrounding LEO plasma is studied by performing leakage current and potential measurements on realistic solar-cell assembly configurations in a simulated high density LEO plasma over a -800 to +800 V voltage range. It is found that the plasma/solar cell interactions are principally controlled by processes occurring in the vicinity of the interconnects, with secondary electron emission from a narrow part of the solar-cell cover glass surface near the interconnects, and ionization of the neutral background gas in front of the module. It is shown that strong electric fields may develop which result in arcing in the positive voltage range above 200 V and in the negative voltage range above -500 V. The module material properties are irreversibly changed by the observed arcing, resulting in the development of new interaction conditions which prevent arcing from recurring at the same location and voltage level.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS LOW EARTH ORBITS SOLAR ARRAYS SOLAR CELLS SPACE PLASMAS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
ELECTRIC POTENTIAL ELECTRON DENSITY (CONCENTRATION) PLASMA DENSITY SPACE ENVIRONMENT SIMULATION VOLT-AMPERE CHARACTERISTICS
Language Note: English
Notes:
ESA Journal (ISSN 0379-2285), vol. 10, no. 1, 1986, p. 43-57.

TITLE: ***LEO high voltage solar array arcing response model***

Document ID: **19870007538** N (87N16971) **File Series**: NASA Technical Reports
Report Number: NASA-CR-180073 NAS 1.26:180073
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Metz, Roger N. (Colby Coll.)
Published: Feb 01, 1987
Corporate Source:
Colby Coll. (Waterville, ME, United States)
Pages: 32
Contract Number: None
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:
A series of mathematical models were developed that describe the electrical behavior of a large solar cell array floating electrically in the low Earth orbit (LEO) space plasma and struck by an arc at a point of negative bias. There are now three models in this series: ARCII, which is a fully analytical, linearized model; ARCIII, which is an extension of ARCIII that includes solar cell inductance as well as load reactance; Nonlinear ARC, which is a numerical model able to treat effects such as non-linearized, i.e., logarithmic solar cell I/V characteristics, conductance switching as a solar cell crosses plasma ground on a voltage excursion and non-ohmic plasma leakage current collection.
Major Subject Terms:
ELECTRICAL PROPERTIES MATHEMATICAL MODELS SOLAR ARRAYS SOLAR CELLS SPACE PLASMAS
Minor Subject Terms:
ALGORITHMS COMPUTER PROGRAMS LEAKAGE LOW EARTH ORBITS SWITCHING
Language Note: English

TITLE: ***High voltage characteristics of the electrodynamic tether and the generation of power and propulsion***

Document ID: **19870003176** N (87N12609) **File Series**: NASA Technical Reports
Report Number: NASA-CR-178949 NAS 1.26:178949
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Williamson, P. R. (Stanford Univ.)
Published: Jan 23, 1986
Corporate Source:
Stanford Univ. (CA, United States)
Pages: 15
Contract Number: NAS8-35502
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The Tethered Satellite System (TSS) will deploy and retrieve a satellite from the Space Shuttle orbiter with a tether of up to 100 km in length attached between the satellite and the orbiter. The characteristics of the TSS which are related to high voltages, electrical currents, energy storage, power, and the generation of plasma waves are described. A number of specific features of the tether system of importance in assessing the operational characteristics of the electrodynamic TSS are identified.
Major Subject Terms:
ELECTRODYNAMICS PAYLOAD RETRIEVAL (STS) SAFETY FACTORS SPACE SHUTTLE PAYLOADS STRUCTURAL DESIGN TETHERED SATELLITES
Minor Subject Terms:
ELECTRIC CURRENT ELECTRIC FIELDS ENERGY STORAGE MAGNETIC FIELDS PLASMAS (PHYSICS)
Language Note: English

TITLE: ***Working group report on advanced high-voltage high-power and energy-storage space systems***

Document ID: **19870010625** N (87N20058) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A04

Authors:

Cohen, H. A. (Jet Propulsion Lab., California Inst. of Tech.) Cooke, D. L. (Jet Propulsion Lab., California Inst. of Tech.) Evans, R. W. (Jet Propulsion Lab., California Inst. of Tech.) Hastings, D. (Jet Propulsion Lab., California Inst. of Tech.) Jongeward, G. (Jet Propulsion Lab., California Inst. of Tech.) Laframboise, J. G. (Jet Propulsion Lab., California Inst. of Tech.) Mahaffey, D. (Jet Propulsion Lab., California Inst. of Tech.) Mcintyre, B. (Jet Propulsion Lab., California Inst. of Tech.) Pfizer, K. A. (Jet Propulsion Lab., California Inst. of Tech.) Purvis, C. (Jet Propulsion Lab., California Inst. of Tech.)

Journal Title: Space Technology Plasma Issues in 2001 **Page**: p 12-15
Published: Oct 01, 1986

Corporate Source:

Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)

Pages: 4
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION

Abstract:

Space systems in the future will probably include high-voltage, high-power energy-storage and -production systems. Two such technologies are high-voltage ac and dc systems and high-power electrodynamic tethers. The working group identified several plasma interaction phenomena that will occur in the operation of these power systems. The working group felt that building an understanding of these critical interaction issues meant that several gaps in our knowledge had to be filled, and that certain aspects of dc power systems have become fairly well understood. Examples of these current collection are in quiescent plasmas and snap over effects. However, high-voltage dc and almost all ac phenomena are, at best, inadequately understood. In addition, there is major uncertainty in the knowledge of coupling between plasmas and large scale current flows in space plasmas. These gaps in the knowledge are addressed.

Major Subject Terms:

AEROSPACE SYSTEMS ENERGY STORAGE HIGH VOLTAGES PLASMA INTERACTIONS

Minor Subject Terms:

AEROSPACE ENVIRONMENTS ARC DISCHARGES ELECTRODYNAMICS ELECTROMAGNETIC INTERACTIONS TETHERLINES

Language Note: English

Notes:

In its Space Technology Plasma Issues in 2001 p 12-15 (SEE N87-20055 12-75)

TITLE: ***A review of the findings of the plasma diagnostic package and associated laboratory experiments: Implications of large body/plasma interactions for future space technology***

Document ID: **19870010639** N (87N20072) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03   CASI Microfiche A04
Authors:
Murphy, Gerald B. (Iowa Univ.)   Lonngren, Karl E. (Iowa Univ.)
Journal Title: JPL, Space Technology Plasma Issues in 2001   **Page**: p 237-248
Published: Oct 01, 1986
Corporate Source:
Iowa Univ. (Iowa City, IA, United States)
Pages: 12
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
The discoveries and experiments of the Plasma Diagnostic Package (PDP) on the OSS 1 and Spacelab 2 missions are reviewed, these results are compared with those of other space and laboratory experiments, and the implications for the understanding of large body interactions in a low Earth orbit (LEO) plasma environment are discussed. First a brief review of the PDP investigation, its instrumentation and experiments is presented. Next a summary of PDP results along with a comparison of those results with similar space or laboratory experiments is given. Last of all the implications of these results in terms of understanding fundamental physical processes that take place with large bodies in LEO is discussed and experiments to deal with these vital questions are suggested.
Major Subject Terms:
PLASMA DIAGNOSTICS   PLASMA INTERACTIONS   SPACE PLASMAS   SPACE SHUTTLE PAYLOADS   SPACEBORNE EXPERIMENTS
Minor Subject Terms:
EARTH ORBITAL ENVIRONMENTS   ELECTROMAGNETIC INTERACTIONS   LOW EARTH ORBITS   NEUTRAL SHEETS   SPACECRAFT ENVIRONMENTS
Language Note: English
Notes:
In JPL, Space Technology Plasma Issues in 2001 p 237-248 (SEE N87-20055 12-75)

TITLE: ***Large manned systems/environment interactions in Low Earth Orbit (LEO)***

Document ID: **19870010645** N (87N20078) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Raitt, W. J. (Utah State Univ.)
Journal Title: JPL, Space Technology Plasma Issues in 2001 **Page**: p 309
Published: Oct 01, 1986
Corporate Source:
Utah State Univ. (Logan, UT, United States)
Pages: 1
Contract Number: None
NASA Subject Category: GEOPHYSICS
Abstract:
With the advent of the NASA Space Transportation System, regular flights of a large manned spacecraft, the Space Shuttle Orbiter, became a reality. From the earliest mission containing space science instruments as a payload on the third flight of the Orbiter (STS-3), it became apparent that the disturbance caused by the interaction of this orbiting system with the low Earth orbit (LEO) environment resulted in adverse conditions for the performance of scientific observations of the Orbiter natural environment and for certain high sensitivity optical observations. The interaction of the Space Shuttle Orbiter system can be divided into two parts, the structure-environment interaction, and the outgas cloud-environment interaction. These interaction are briefly discussed.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS LOW EARTH ORBITS PLASMA INTERACTIONS PLASMA TURBULENCE SPACE PLASMAS
Minor Subject Terms:
OUTGASSING SPACE SHUTTLE PAYLOADS SPACEBORNE EXPERIMENTS SPACECRAFT ENVIRONMENTS
Language Note: English
Notes:
In JPL, Space Technology Plasma Issues in 2001 p 309 (SEE N87-20055 12-75)

TITLE: ***Computer models of the spacecraft wake***

Document ID: **19870010651** N (87N20084) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:

Rubin, A. G. (Air Force Geophysics Lab.) Heinemann, M. (Air Force Geophysics Lab.) Tautz, M. (RADEX, Inc.) Cooke, D. (Air Force Geophysics Lab.)

Journal Title: JPL, Space Technology Plasma Issues in 2001 **Page**: p 313
Published: Oct 01, 1986
Corporate Source:

Air Force Geophysics Lab. (Hanscom AFB, MA, United States)

Pages: 1
Contract Number: None
NASA Subject Category: COMPUTER PROGRAMMING AND SOFTWARE
Abstract:

Until recently, computations of space plasma flow over a spacecraft have been unstable for ratios of spacecraft dimension to Debye length typical of the low Earth orbit environment. Calculations are presented of the spacecraft/environment interaction based on two computer codes, MACH and POLAR. MACH, an inside-out particle tracking code, was developed for the purpose of validating the physics of POLAR in regimes where these are no comprehensive theoretical or experimental results. While the spacecraft which can be treated by MACH are restricted to simple geometries, the methodology is more fundamental than POLAR. MACH generates self-consistent solutions within the context of quasisteady Vlasov plasma flow and achieves Debye ratios previously unobtainable. POLAR uses a three-dimensional finite-element representation of the vehicle in a staggered mesh. The plasma sheath is modeled by outside-in particle tracking. Solutions for the plasma flow, wake and vehicle charging are obtained by Vlasov-Poisson iteration; charge stabilization techniques make the results virtually insensitive to the Debye ratio. POLAR reproduces the Laframboise static plasma solutions for sperical probes and fits the Makita-Kuriki probe data for spheres in a flowing plasma in regions where comparisons are valid. POLAR and MACH solutions for the particle and electrostatic potential structure of the wake of a charged disk in a low-altitude flow are shown for Mach numbers 4, 5, and 8. New features of the solutions include ion focussing in the wake and a definitive determination of the sheath edge in the wake which shows that the sheath is not an equipotential.

Major Subject Terms:

COMPUTER PROGRAMS EARTH ORBITAL ENVIRONMENTS MAGNETOHYDRODYNAMIC FLOW SPACE PLASMAS SPACECRAFT ENVIRONMENTS TURBULENT WAKES

Minor Subject Terms:

ELECTROSTATIC CHARGE FINITE ELEMENT METHOD LOW EARTH ORBITS PARTICLE TRACKS PLASMA SHEATHS RADIATION EFFECTS SPACECRAFT CHARGING

Language Note: English
Notes:

In JPL, Space Technology Plasma Issues in 2001 p 313 (SEE N87-20055 12-75)

TITLE: ***Space-charge-induced breakdown in dielectrics***

Document ID: **19870011596** N (87N21029) **File Series**: NASA Technical Reports
Report Number: AD-A176969 AFOSR-87-0183TR
Sales Agency & Price: CASI Hardcopy A04 CASI Microfiche A01
Authors:

Cooke, Chathan M. (Massachusetts Inst. of Tech.)

Published: Jan 01, 1986
Corporate Source:

Massachusetts Inst. of Tech. (Cambridge, MA, United States)

Pages: 57
Contract Number: AF-AFOSR-0107-84
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

The work included experimental tests and theoretical modeling of space charge effects. The tests employed energetic electron beams as a means to inject controlled quantities of charge into test specimens. The use of electron beams is relevant to certain practical applications such as radiation effects and spacecraft charging, as well as being an important diagnostic tool for dielectric materials and for e-beam transport studies.

Major Subject Terms:
CHARGE TRANSFER DIELECTRICS ELECTRICAL FAULTS SPACE CHARGE SPACECRAFT CHARGING
Minor Subject Terms:
BEAM INJECTION ELECTRON BEAMS POISSON EQUATION RADIATION EFFECTS SPACECRAFT ENVIRONMENTS TRANSPORT THEORY
Language Note: English

TITLE: ***A laboratory investigation of potential double layers***

Document ID: **19870013884** N (87N23317) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A03
Authors:
Leung, Philip (Jet Propulsion Lab., California Inst. of Tech.)
Journal Title: NASA. Marshall Space Flight Center Double Layers in Astrophysics **Page**: p 89-103
Published: May 01, 1987
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 15
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
In a triple plasma device, the injection of electron current from the source chamber to the target chamber causes the formation of a potential double layer. At a low current density, the space charge of the injected current produces a virtual cathode-type potential double layer. This double layer is stable, and various wave instabilities are observed to associate with this double layer. As the current density is increased, the double layer becomes unstable, and a moving double layer results. As the current density is increased further, the enhanced ionization causes the neutralization of the space charge of the electron beam, and the beam plasma discharge is ignited.
Major Subject Terms:
ELECTRIC FIELDS ELECTRON PLASMA MAGNETOHYDRODYNAMIC STABILITY PLASMA LAYERS PLASMA POTENTIALS SPACE CHARGE
Minor Subject Terms:
CURRENT DENSITY ELECTRON DISTRIBUTION PLASMA CURRENTS PLASMA JETS
Language Note: English
Notes:
In NASA. Marshall Space Flight Center Double Layers in Astrophysics p 89-103 (SEE N87-23313 16-88)

TITLE: ***Computer models of the spacecraft wake***

Document ID: **19870017515** N (87N26948) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A03 - Copyright
Authors:
Heinemann, M. (Air Force Geophysics Lab.) Rubin, A. (Air Force Geophysics Lab.) Tautz, M. (Air Force Geophysics Lab.) Cooke, D. (RADEX, Inc.)
Journal Title: AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications **Page**: 9 p
Published: May 01, 1987
Corporate Source:
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 9
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The Mesothermal Auroral Charging (MACH) code, an inside-out particle tracking code, was developed for the purpose of validating the physics of the Potential Of Large Spacecraft in the Auroral Regions (POLAR) code in regimes where there can be no comprehensive theoretical or experimental results. While the spacecraft that can be treated by MACH are restricted to simple geometries, the methodology is more fundamental than POLAR. MACH generates self-consistent solutions within the context of quasisteady Vlasov plasma flow and achieves Debye ratios previously unobtainable. POLAR and MACH solutions are shown for the particle and electrostatic potential structure of the wake of a charged disk in a low altitude flow for Mach numbers 4, 5, and 8. The results of the codes are compared to each other and to simple analytic approximations as part of an effort to compute the nature of the spacecraft wake and to establish the validity of the codes.
Major Subject Terms:
COMPUTER PROGRAMS PLASMA SHEATHS SPACE PLASMAS SPACECRAFT DESIGN TRACKING (POSITION) WAKES
Minor Subject Terms:
COMPUTATION FINITE ELEMENT METHOD PROVING
Language Note: English
Notes:
In AGARD, The Aerospace Environment at High Altitudes and its Implications for Spacecraft Charging and Communications 9 p (SEE N87-26937 21-18)

TITLE: ***Computer modeling of high-voltage solar array experiment using the NASCAP/LEO (NASA Charging Analyzer Program/Low Earth Orbit) computer code***

Document ID: **19870018753** N (87N28186) **File Series**: NASA Technical Reports
Report Number: AD-A182589 AFIT/GE/ENG/87J-2
Sales Agency & Price: CASI Hardcopy A10 CASI Microfiche A03
Authors:
Reichl, Karl O., Jr. (Air Force Inst. of Tech.)
Published: Jun 01, 1987
Corporate Source:
Air Force Inst. of Tech. (Wright-Patterson AFB, OH, United States)
Pages: 211
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The relationship between the Interactions Measurement Payload for Shuttle (IMPS) flight experiment and the low Earth orbit plasma environment is discussed. Two interactions (parasitic current loss and electrostatic discharge on the array) may be detrimental to mission effectiveness. They result from the spacecraft's electrical potentials floating relative to plasma ground to achieve a charge flow equilibrium into the spacecraft. The floating potentials were driven by external biases applied to a solar array module of the Photovoltaic Array Space Power (PASP) experiment aboard the IMPS test pallet. The modeling was performed using the NASA Charging Analyzer Program/Low Earth Orbit (NASCAP/LEO) computer code which calculates the potentials and current collection of high-voltage objects in low Earth orbit. Models are developed by specifying the spacecraft, environment, and orbital parameters. Eight IMPS models were developed by varying the array's bias voltage and altering its orientation relative to its motion. The code modeled a typical low Earth equatorial orbit. NASCAP/LEO calculated a wide variety of possible floating potential and current collection scenarios. These varied directly with both the array bias voltage and with the vehicle's orbital orientation.
Major Subject Terms:
COMPUTER PROGRAMS COMPUTERIZED SIMULATION EARTH ORBITS ELECTRIC DISCHARGES FLIGHT TESTS HIGH VOLTAGES LOW EARTH ORBITS PLASMA EQUILIBRIUM PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS SPACECRAFT ORBITS TRAJECTORIES
Minor Subject Terms:
AEROSPACE SYSTEMS ANALYZERS BEARING (DIRECTION) CHARGE TRANSFER ELECTRICAL MEASUREMENT ELECTRICAL PROPERTIES EQUATORIAL ORBITS FLOATING MODULES PARASITES PAYLOADS PHOTOVOLTAIC EFFECT
Language Note: English

TITLE: ***Three dimensional simulation of the operation of a hollow cathode electron emitter on the Shuttle orbiter***

Document ID: **19870026810** A (87A14084) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Davis, V. A. (Systems Science and Software) Katz, I. (Systems Science and Software) Mandell, M. J. (Systems Science and Software) Parks, D. E. (Systems Science and Software)
Published: Sep 01, 1986
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 16
Contract Number: NAS3-23881
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:
Several researchers have suggested using hollow cathodes as plasma contactors for electrodynamic tethers, particularly to prevent the shuttle orbiter from charging to large negative potentials. Previous studies have shown that fluid models with anomalous scattering can describe the electron transport in hollow cathode generated plasmas. An improved theory of the hollow cathode plasmas is developed and computational results using the theory are compared with laboratory experiment. Numerical predictions for a hollow cathode plasma source of the type considered for use on the shuttle are presented as are three-dimensional NASCAP/LEO calculations of the emitted ion trajectories and the resulting potentials in the vicinity of the orbiter. The computer calculations show that the hollow cathode plasma source makes vastly superior contact with the ionospheric plasma compared with either an electron gun or passive ion collection by the orbiter.
Major Subject Terms:
ELECTRON EMISSION HOLLOW CATHODES SPACE SHUTTLE ORBITERS SPACECRAFT CHARGING TETHERLINES THREE DIMENSIONAL MODELS
Minor Subject Terms:
SIMULATION SPACE PLASMAS
Language Note: English
Notes:
NASA, AIAA, and PSN, International Conference on Tethers in Space, Arlington, VA, Sept. 17-19, 1986, Paper. 16 p.

TITLE: ***Development of the VOLT-A Shuttle experiment***

Document ID: **19870032633** A (87A19907) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:

Bifano, William J. (NASA Lewis Research Center) Bozek, John M. (NASA Lewis Research Center) Ferguson, Dale C. (NASA Lewis Research Center)

Published: Jan 01, 1985
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 8
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

The NASA Lewis Research Center (LeRC) is investigating potential problems associated with the operation of high voltage solar cell arrays in the space plasma environment. At high voltages, interactions between the solar array and the space plasma could result in unacceptable levels of electrical discharge (arcing) and/or parasitic losses (current drains from the array to the plasma). The objective of the Voltage Operating Limit Tests (VOLT-A) Shuttle bay experiment is to characterize space plasma/solar cell panel interactions in low earth orbit. VOLT-A consists of an experiment plate subassembly which contains four solar panels, an electronics subassembly and a Langmuir probe subassembly mounted on an MPESS carrier. During a given 8.25 hour data taking period (5-1/2 continuous orbits), the solar panels, which represent state-of-the-art solar cell technologies, will be sequentially subjected to bias voltages in steps ranging from minus 626 V to plus 313 V. Appropriate measurements will be made at each voltage to characterize arcing and parasitic losses. Corresponding measurements of the plasma environment (plasma density, electron temperature and neutral density) will also be made. Data will be recorded on an on-board tape recorder for subsequent data reduction and analysis.

Major Subject Terms:

EARTH ORBITS HIGH VOLTAGES LOSSES SOLAR CELLS SPACE PLASMAS

Minor Subject Terms:

AEROSPACE ENVIRONMENTS ARC DISCHARGES ELECTRIC ARCS ELECTRIC POTENTIAL LOW EARTH ORBITS SPACEBORNE EXPERIMENTS

Language Note: English
Notes:

IN: Photovoltaic Specialists Conference, 18th, Las Vegas, NV, October 21-25, 1985, Conference Record (A87-19826 07-44). New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 680-687. Previously announced in STAR as N86-14110.

TITLE: ***Plasma interactions with biased concentrator solar cells***

Document ID: **19870034720** A (87A21994) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Stillwell, R. P. Stevens, N. J. (TRW, Inc.)

Journal Title: IEEE Transactions on Nuclear Science **Volume**: NS-33 **Page**: 1402-140
Published: Dec 01, 1986
Corporate Source:

(Corporate Source(s) Not Available)

Pages: 6
Contract Number: None
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:

Concentrator solar arrays are being proposed for future space missions as replacements for less efficient (power/mass) planar arrays. While planar solar arrays have been used in space and their characteristics evaluated, concentrator cell interactions have not. This study investigates the possible interactions between a biased concentrator cell and a plasma environment. This study involved experimental and preliminary analytical work. It has been found that the electric fields associated with the biased cell are confined to the light collector region of the cell configuration, and that the cell arcs in dense plasma environments, at negative voltages of less than -200 volts, in a way similar to the arcing experienced by planar cells.

Major Subject Terms:

PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS SPACE PLASMAS SPACECRAFT POWER SUPPLIES

Minor Subject Terms:

CONCENTRATORS CURRENT DENSITY DENSE PLASMAS ELECTRIC ARCS ELECTRON DENSITY (CONCENTRATION) ION CURRENTS

Language Note: English
Notes:

(IEEE, DNA, Sandia National Laboratories, and NASA, 1986 Annual Conference on Nuclear and Space Radiation Effects, 23rd, Providence, RI, July 21-23, 1986) IEEE Transactions on Nuclear Science (ISSN 0018-9499), vol. NS-33, Dec. 1986, pt. 1, p. 1402-1407.

TITLE: ***Space plasma charging - Lessons from Voyager***

Document ID: **19870035384** A (87A22658) **File Series**: Open Literature
Report Number: AIAA PAPER 87-0474
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Whittlesey, A. (Jet Propulsion Lab., California Inst. of Tech.) Leung, P. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena)
Published: Jan 01, 1987
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 5
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The Voyager spacecraft to Jupiter and beyond was designed with the intent that it would be immune to the deleterious effects of space plasma charging. Such effects include electrostatic fields disrupting science data, external electrostatic discharge (ESD) events, and also internal ESDs. This paper describes the design features incorporated into the Voyager spacecraft, the rationale for those features, the results in the Jovian environment, and present thinking about appropriate design to avoid ESD problems caused by space charging.
Major Subject Terms:
ELECTRIC DISCHARGES SPACE PLASMAS SPACECRAFT CHARGING VOYAGER PROJECT
Minor Subject Terms:
JUPITER ATMOSPHERE PLANETARY MAGNETIC FIELDS SPACECRAFT CONSTRUCTION MATERIALS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 5 p. NASA-supported research.

TITLE: ***Hollow cathodes as electron emitting plasma contactors Theory and computer modeling***

Document ID: **19870035438** A (87A22712) **File Series**: Open Literature
Report Number: AIAA PAPER 87-0569
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Davis, V. A. (Systems Science and Software) Katz, I. (Systems Science and Software) Mandell, M. J. (Systems Science and Software) Parks, D. E. (Systems Science and Software)
Published: Jan 01, 1987
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 7
Contract Number: NAS3-23881
NASA Subject Category: PLASMA PHYSICS
Abstract:
Several researchers have suggested using hollow cathodes as plasma contactors for electrodynamic tethers, particularly to prevent the Shuttle Orbiter from charging to large negative potentials. Previous studies have shown that fluid models with anomalous scattering can describe the electron transport in hollow cathode generated plasmas. An improved theory of the hollow cathode plasmas is developed and computational results using the theory are compared with laboratory experiments. Numerical predictions for a hollow cathode plasma source of the type considered for use on the Shuttle are presented, as are three-dimensional NASCAP/LEO calculations of the emitted ion trajectories and the resulting potentials in the vicinity of the Orbiter. The computer calculations show that the hollow cathode plasma source makes vastly superior contact with the ionospheric plasma compared with either an electron gun or passive ion collection by the Orbiter.
Major Subject Terms:
ELECTRIC RELAYS ELECTRON EMISSION HOLLOW CATHODES PLASMA POTENTIALS SPACECRAFT CHARGING
Minor Subject Terms:
COMPUTERIZED SIMULATION CONSERVATION EQUATIONS ION CURRENTS SPACE SHUTTLE ORBITERS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 25th, Reno, NV, Jan. 12-15, 1987. 7 p.

TITLE: ***Measurements of plasma parameters in the vicinity of the Space Shuttle***

Document ID: **19870037398 A** (87A24672) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Murphy, G. (Iowa Univ.) Pickett, J. (Iowa Univ.) Dangelo, N. (Iowa Univ.) Kurth, W. S. (Iowa, University)
Journal Title: Planetary and Space Science **Volume**: 34 **Page**: 993-1004
Published: Oct 01, 1986
Corporate Source:
Iowa Univ. (Iowa City, IA, United States)
Pages: 12
Contract Number: NAS8-32807
NASA Subject Category: GEOPHYSICS
Abstract:
A Langmuir probe flown as part of the Plasma Diagnostics Package aboard the third Space **Shuttle** flight was used to determine electron densities, temperatures, and plasma potential in the vicinity of the **Shuttle** Orbiter. Measurements taken both in the cargo bay and 10 m above the cargo bay on the Remote Manipulator System arm are consistent with small satellite and laboratory results, in that reduced densities and elevated temperatures are observed in the **Shuttle wake**. The primary difference in the **Shuttle** measurements is one of magnitude; i.e., orders-of-magnitude density decreases and factor-of-five temperature enhancements. Analysis of data taken in (Delta N)/N turbulence can be as high as a few percent, and the most intense turbulence seems to occur near regions with a steep gradient in plasma pressure.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTROSTATIC PROBES PLASMA DIAGNOSTICS SPACE **SHUTTLE** ORBITERS
Minor Subject Terms:
ELECTRON DENSITY (CONCENTRATION) ELECTRON ENERGY PLASMA DENSITY PLASMA POTENTIALS PLASMA PRESSURE
Language Note: English
Notes:
Planetary and Space Science (ISSN 0032-0633), vol. 34, Oct. 1986, p. 993-1004.

TITLE: ***v(vector) x B(vector) and density gradient electric fields measured from spacecraft***

Document ID: **19870038420** A (87A25694) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Lilley, J. R., Jr. Katz, I. Cooke, D. L. (Systems Science and Software)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 23 **Page**: 656-658
Published: Dec 01, 1986
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 3
Contract Number: F19628-82-C-0081
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Density gradients and v(vector) x B(vector) are two environmental factors causing electric fields on spacecraft in low earth orbit, such as the Space Shuttle Orbiter. It is presently demonstrated that care must be taken when interpreting space potential or plasma electric field measurements, since plasma parameters, geometrical effects, and velocity effects may obscure the source of observed electric fields.
Major Subject Terms:
ELECTRIC FIELDS SPACE PLASMAS SPACECRAFT CHARGING
Minor Subject Terms:
ARTIFICIAL SATELLITES ELECTRON DENSITY (CONCENTRATION) LOW EARTH ORBITS PLASMA DENSITY SPACE SHUTTLE ORBITERS
Language Note: English
Notes:
Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, Nov.-Dec. 1986, p. 656-658.

TITLE: ***Characteristics of electromagnetic interference generated by arc discharges***

Document ID: **19870042173** A (87A29447) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Leung, Philip (California Institute of Technology)
Published: Jan 01, 1986
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 5
Contract Number: None
NASA Subject Category: GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)
Abstract:
Electromagnetic interference (EMI) signatures resulting from arc discharges are characterized, and the effects of electrostatic discharges (ESDs) on the design of spacecraft systems are investigated. EMI characterization experiments were performed on Mylar, Teflon, Kapton, fused silica, and fiberglass in a vacuum chamber with acrylic walls; the experimental design and procedures are described. Discharge current pulses and RF spectra generated by the sample materials are examined. The relation between the magnitude of EMI generated during an ESD event and the material, environment, and geometry is studied. The solar-array/plasma interaction is analyzed; particular attention is given to the rate of discharge as a function of plasma density. The physical mechanisms of ESD-generated EMI are discussed. The data reveal that ESD parameters are dependent on the test environment.
Major Subject Terms:
ARC DISCHARGES • ELECTROMAGNETIC INTERFERENCE • ELECTROSTATIC CHARGE • SPACECRAFT CHARGING
Minor Subject Terms:
COST EFFECTIVENESS • DIELECTRICS • KAPTON (TRADEMARK) • MYLAR (TRADEMARK) • PLASMA DENSITY • RADIO SPECTRA • SILICON DIOXIDE • SOLAR ARRAYS • TEFLON (TRADEMARK)
Language Note: English
Notes:
IN: Aerospace Testing Seminar, 9th, Los Angeles, CA, Oct. 15-17, 1985, Proceedings (A87-29441 11-14). Mount Prospect, IL, Institute of Environmental Sciences, 1986, p. 40-44.

TITLE: ***Laboratory simulation of plasma interaction with high voltage solar array***

Document ID: **19870045114** A (87A32388) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Fujii, Haruhisa · Shibuya, Yoshikazu (Mitsubishi Electric Corp.) · Abe, Toshio · Ijichi, Koichi · Kasai, Ritaroh (Mitsubishi Electric Corp.)

Published: Jan 01, 1986
Corporate Source:

(Corporate Source(s) Not Available)

Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

The interactions of solar arrays operating at a high voltage with dense plasma are investigated. Glass-covered aluminum plates simulating the solar arrays were subjected to dc potentials in a plasma-filled space chamber. When negative voltage was applied, arcing discharge occurred at the voltage less than 1000 V. The breakdown voltage decreased with increasing plasma density. The existence of the insulating cover glasses is found to lower the discharge voltage. In the case of positive polarity, however, no discharge occurred at the potential up to 1000 V.

Major Subject Terms:

PLASMA INTERACTIONS · SOLAR ARRAYS · SPACE SIMULATORS · SPACECRAFT POWER SUPPLIES

Minor Subject Terms:

ARC DISCHARGES · DENSE PLASMAS · ELECTRICAL FAULTS · ELECTRICAL INSULATION · HIGH VOLTAGES · RELIABILITY ENGINEERING

Language Note: English
Notes:

IN: International Symposium on Space Technology and Science, 15th, Tokyo, Japan, May 19-23, 1986, Proceedings. Volume 1 (A87-32276 13-12). Tokyo, AGNE Publishing, Inc., 1986, p. 825-830.

TITLE: ***Plasma electron collection through biased slits in a dielectric***

Document ID: **19870043949** A (87A31223) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Carruth, M. R., Jr. (NASA Marshall Space Flight Center)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 24 **Page**: 79-85
Published: Feb 01, 1987
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 7
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
A large number of experimental and analytical efforts have been directed toward understanding the plasma sheath growth and discharge phenomena which lead to high-voltage solar array/space plasma interactions. An important question which has not been addressed is how the voltage gradient in the plasma sheath near the surface of such an array may affect these interactions. The purpose of the experimental study described in this paper is to examine the merging of the sheaths around biased slits in a dielectric and how this affects the collection of electrons through these slits. The data, which are obtained by emissive probes and direct measurement of the current collected through the slits, indicate that when the sheaths merge the current collection by the slits is significantly altered with the most positive slit collecting more electrons than it otherwise would. Therefore, the effect of a voltage gradient in the sheath around a solar array should be considered when evaluating solar array performance.
Major Subject Terms:
ELECTRON PLASMA PLASMA INTERACTIONS PLASMA SHEATHS SOLAR ARRAYS SPACE PLASMAS SPACECRAFT CHARGING
Minor Subject Terms:
DIELECTRICS ELECTRIC POTENTIAL ELECTRON DISTRIBUTION PLASMA DIAGNOSTICS
Language Note: English
Notes:
Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 24, Jan.-Feb. 1987, p. 79-85.

TITLE: ***The voltage threshold for arcing for solar cells in Leo - Flight and ground test results***

Document ID: **19870053001** A (87A40275) **File Series**: Open Literature
Report Number: AIAA PAPER 86-0362
Sales Agency & Price: Issuing Activity
Authors:
Ferguson, Dale C. (NASA Lewis Research Center)
Published: Jan 01, 1986
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 25
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Ground and flight results of solar cell arcing in low earth orbit (LEO) conditions are compared and interpreted. It is shown that an apparent voltage threshold for arcing may be produced by a storage power law dependence of arc rate on voltage, combined with a limited observation time. The change in this apparent threshold with plasma density is a reflection of the density dependence of the arc rate. A nearly linear dependence of arc rate on density is inferred from the data. A real voltage threshold for arcing for 2 by 2 cm solar cells may exist however, independent of plasma density, near -230 V relative to the plasma. Here, arc rates may change by more than an order of magnitude for a change of only 30 V in array potential. For 5.9 by 5.9 solar cells, the voltage dependence of the arc rate is steeper, and the data are insufficient to indicate the existence of an arcing increased by an atomic oxygen plasma, as is found in LEO, and by arcing from the backs of welded-through substrates.
Major Subject Terms:
EARTH ORBITS ELECTRIC ARCS FLIGHT TESTS PLASMA DENSITY SOLAR CELLS STRUCTURAL DESIGN
Minor Subject Terms:
ELECTRIC POTENTIAL ELECTRON ENERGY ELECTRON TUNNELING ELECTROSTATIC PROBES LOW EARTH ORBITS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 24th, Reno, NV, Jan. 6-9, 1986. 25 p. Previously announced in STAR as N86-28125.

TITLE: ***MSIS-86 thermospheric model***

Document ID: 19870053927 A (87A41201) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:

Hedin, Alan E. (NASA Goddard Space Flight Center)

Journal Title: Journal of Geophysical Research **Volume**: 92 **Page**: 4649-466
Published: May 01, 1987
Corporate Source:

NASA Goddard Space Flight Center (Greenbelt, MD, United States)

Pages: 14
Contract Number: None
NASA Subject Category: GEOPHYSICS
Abstract:

The **MSIS**-86 empirical model of thermospheric temperature, density and composition uses new temperature and composition data from the Dynamics Explorer satellite to improve the representation of polar region morphology over that in the **MSIS**-83 model. Terms were added or changed to better represent seasonal variations in the polar regions under both quiet and magnetically disturbed conditions. Local time variations in the magnetic activity effect were added. In addition a new species, atomic nitrogen, was added to the previous list of N2, O2, He, O, H, and Ar covered by the model.

Major Subject Terms:

ATMOSPHERIC COMPOSITION ATMOSPHERIC DENSITY ATMOSPHERIC MODELS ATMOSPHERIC TEMPERATURE DYNAMICS EXPLORER SATELLITES THERMOSPHERE

Minor Subject Terms:

ANNUAL VARIATIONS EXTREME ULTRAVIOLET RADIATION SOLAR ACTIVITY SOLAR RADIATION

Language Note: English
Notes:

Journal of Geophysical Research (ISSN 0148-0227), vol. 92, May 1, 1987, p. 4649-4662.

TITLE: ***A laboratory investigation of potential double layers***

Document ID: **19870057873** A (87A45147) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Leung, Philip (California Institute of Technology)
Journal Title: Laser and Particle Beams **Volume**: 5 **Page**: 339-349
Published: May 01, 1987
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 11
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
In a triple plasma device, the injection of electron current from the source chamber to the target chamber causes the formation of a potential double layer. At a low current density, the space charge of the injected current produces a virtual cathode-type potential double layer. This double layer is stable and various wave instabilities are observed to associate with this double layer. As the current density is increased, the double layer becomes unstable and a moving double layer results. As the current density is increased further, the enhanced ionization causes the neutralization of the space charge of the electron beam and the 'beam plasma discharge' is ignited.
Major Subject Terms:
ELECTRON PLASMA PLASMA DIAGNOSTICS PLASMA LAYERS PLASMA POTENTIALS
Minor Subject Terms:
MAGNETOHYDRODYNAMIC STABILITY PLASMA CURRENTS PLASMA ELECTRODES PLASMA JETS PLASMA TURBULENCE SPACE CHARGE
Language Note: English
Notes:
(NASA, Conference on Double Layers in Plasmas, Huntsville, AL, Mar. 1986) Laser and Particle Beams (ISSN 0263-0346), vol. 5, May 1987, pt. 2, p. 339-349.

TITLE: ***Ram ion scattering caused by Space Shuttle v x B induced differential charging***

Document ID: **19870064439** A (87A51713) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Katz, I. (Maxwell Labs., Inc.) Davis, V. A. (Maxwell Laboratories, Inc.)
Journal Title: Journal of Geophysical Research **Volume**: 92 **Page**: 8787-879
Published: Aug 01, 1987
Corporate Source:
Maxwell Labs., Inc. (San Diego, CA, United States)
Pages: 5
Contract Number: NAS3-23881
NASA Subject Category: GEOPHYSICS
Abstract:
Observations of secondary, high-inclination ions streams have been reported in the literature. The authors of these previous papers attributed the source of the secondary ions to a disturbed region in the plasma about 10 m from the Space Shuttle Orbiter. A new theory has been developed which shows how v x B induced differential charging on the plasma diagnostics package (PDP) can scatter the ram ion flux. Some of these ions are reflected back to the PDP and may be the sorce of the observed ion distributions. The effect is unique to large spacecraft; it occurs only when the magnitude of the induced v x B potentials are much larger than the electron thermal energy and of the order of the ion ram energy. That the ion streams observed at large angles must have been reflected from the PDP surface is demonstrated with three-dimensional sheath and particle trajectory calculations using the low earth orbit version of the NASA Charging Analyzer Program (NASCAP/LEO).
Major Subject Terms:
ION SCATTERING SPACE SHUTTLES SPACEBORNE EXPERIMENTS SPACECRAFT CHARGING
Minor Subject Terms:
ELECTRON ENERGY LARGE SPACE STRUCTURES LOW EARTH ORBITS PLASMA DIAGNOSTICS REFLECTANCE
Language Note: English
Notes:
Journal of Geophysical Research (ISSN 0148-0227), vol. 92, Aug. 1, 1987, p. 8787-8791.

TITLE: ***The NASA Marshall engineering thermosphere model***

Document ID: 19880017376 N (88N26760) **File Series**: NASA Technical Reports
Report Number: NASA-CR-179359 NAS 1.26:179359
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Hickey, Michael Philip (Universities Space Research Association)
Published: Jul 01, 1988
Corporate Source:
Universities Space Research Association (Huntsville, AL, United States)
Pages: 40
Contract Number: NAS8-36400
NASA Subject Category: GEOPHYSICS
Abstract:
Described is the NASA Marshall Engineering Thermosphere (**MET**) Model, which is a modified version of the MFSC/J70 Orbital Atmospheric Density Model as currently used in the J70MM program at MSFC. The modifications to the MFSC/J70 model required for the **MET** model are described, graphical and numerical examples of the models are included, as is a listing of the **MET** model computer program. Major differences between the numerical output from the **MET** model and the MFSC/J70 model are discussed.
Major Subject Terms:
ATMOSPHERIC MODELS EARTH ATMOSPHERE ENGINEERING MANAGEMENT THERMOSPHERE
Minor Subject Terms:
ATMOSPHERIC DENSITY COMPUTER PROGRAMS GRAPHS (CHARTS) NUMERICAL ANALYSIS REVISIONS
Language Note: English

TITLE: ***Computer models of steady state electron collection by SPEAR I***

Document ID: **19880035092** A (88A22319) **File Series**: Open Literature
Report Number: AIAA PAPER 88-0429
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Cooke, David L. Dubs, Charles (USAF, Geophysics Laboratory, Hanscom AFB) Katz, Ira Jongeward, Gary Mandell, Myron (Systems, Science and Software, La Jolla)

Published: Jan 01, 1988
Corporate Source:

(Corporate Source(s) Not Available)

Pages: 32
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:

In support of the SPEAR rocket experiment, the three dimensional code POLAR has been used to model an electron collecting sphere in a low earth orbit plasma. These models do not predict collection in excess of canonical limits. Results and analysis indicate that the degree of current limiting by the magnetic field is controlled by the parameter q = (omega)p-squared/(omega)c-squared, with q greater than 10 indicating minimal magnetic limiting; q in the range of 1-10, indicating moderate limiting with complex electron motion; and q less than 1 indicating significant limiting. Furthermore, for some arrangements of the collecting surfaces, canonical angular momentum is not conserved, so that if q is greater than 1.0, the magnetic field can no longer prevent the cross field transport of electrons.

Major Subject Terms:

COMPUTERIZED SIMULATION EARTH ORBITAL ENVIRONMENTS ELECTRON PROBES ROCKET SOUNDING SPACE PLASMAS

Minor Subject Terms:

ANGULAR MOMENTUM CANONICAL FORMS GEOMAGNETISM LOW EARTH ORBITS PLASMA TURBULENCE

Language Note: English
Notes:

AIAA, Aerospace Sciences Meeting, 26th, Reno, NV, Jan. 11-14, 1988. 32 p.

TITLE: ***Test program to evaluate ESD susceptibility of EVA suit material***

Document ID: **19880046562** A (88A33789) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Leung, Philip (California Institute of Technology)
Published: Jan 01, 1987
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 6
Contract Number: NAS7-918
NASA Subject Category: GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)
Abstract:
This paper presents the details of a test program for the evaluation of the electrostatic discharge susceptibility of extravehicular activity equipment in polar orbits. In this program, laboratory simulation tests were performed to obtain the charging and ESD characteristics of the spacesuit material. The results from the simulation tests were used to generate the parameters for a system level ESD test for the existing EVA equipment. These test parameters were also used as a guide for the selection of the test apparatus.
Major Subject Terms:
ELECTROSTATIC CHARGE EXTRAVEHICULAR ACTIVITY SPACE SUITS SPACECRAFT CHARGING TEST FACILITIES
Minor Subject Terms:
MATERIALS TESTS POLAR ORBITS SPACE ENVIRONMENT SIMULATION
Language Note: English
Notes:
IN: Aerospace Testing Seminar, 10th, Los Angeles, CA, Mar. 10-12, 1987, Proceedings (A88-33776 13-38). Mount Prospect, IL, Institute of Environmental Sciences, 1987, p. 105-110.
Aerospace Testing Seminar Los Angeles, CA Mar. 10-12, 1987

TITLE: ***Ground testing of array modules for the photovoltaic array space power (PASP) experiment***

Document ID: **19880047117** A (88A34344) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Morris, Robert K. (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB) Grier, Norman T. (NASA Lewis Research Center)
Published: Jan 01, 1987
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 5
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
One of the objectives of the PASP experiment is the verification of cost-effective ground simulations of high-voltage solar array/space-environment interactions by comparing the results with flight data. These ground tests consist of electrical characterization, thermal cycling, and plasma chamber simulations. The results of the latter tests are reported. Five array modules which are representative of the flight arrays were tested. The module types are planar silicon, planar gallium arsenide, planar silicon passivated with an integrally deposited cover glass, mini-Cassegrainian concentrator, and SLATS concentrator. The modules were biased to -1000 V in varying plasma densities from 4 x 103 to 2 x 105 e-/cu cm. Each array was tested in both dark and illuminated conditions with a load resistance. In addition to monitoring arcing during the plasma tests, the arrays were visually inspected and electrically characterized before and after exposure in the chamber. The electrical results are tabulated and briefly discussed.
Major Subject Terms:
GROUND TESTS SOLAR ARRAYS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
GALLIUM ARSENIDES PLASMA DENSITY SILICON SPACE ENVIRONMENT SIMULATION THERMAL CYCLING TESTS VOLT-AMPERE CHARACTERISTICS
Language Note: English
Notes:
IN: IEEE Photovoltaic Specialists Conference, 19th, New Orleans, LA, May 4-8, 1987, Proceedings (A88-34226 13-44). New York, Institute of Electrical and Electronics Engineers, Inc., 1987, p. 669-673.
IEEE Photovoltaic Specialists Conference New Orleans, LA May 4-8, 1987

TITLE: ***SPEAR - Rocket flights to investigate the innovative design of high power space systems***

Document ID: **19880055359** A (88A42586) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Allred, D. B. (DNA) Benson, J. D. (SDIO) Cohen, H. A. (W. J. Schafer Associates, Inc.)
Published: Jan 01, 1988
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 9
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The SPEAR I and SPEAR II sounding rocket flights, will carry the highest exposed voltage systems yet flown in space. SPEAR I was launched December 13, 1987, to investigate the electrical current drain to highly charged objects in the ionosphere. SPEAR I results, augmented with laboratory and theoretical studies, will be used to determine the ambient conditions that would cause discharging and arcing of high power systems in space. These results will then be used for the design, test and flight of high power systems. SPEAR II, scheduled for launch in early 1989, will involve the innovative operations of high voltage and high current systems in the ionosphere. These flight programs utilize theoretical research efforts of several groups, as well as vacuum and plasma chamber testing of high power systems. Innovative aspects will include the exposure of uninsulated transmission and pulse forming systems to the ambient plasma, the charging and use of high energy storage systems during flight, and the use of high voltage and high current loads not previously used in space. Unique problems include outgassing, mitigation of electrical breakdown, loading, and the use of innovative spacecraft integration techniques for commands and telemetry to high voltage systems.
Major Subject Terms:
HIGH CURRENT HIGH VOLTAGES IONOSPHERIC SOUNDING ROCKET-BORNE INSTRUMENTS SOUNDING ROCKETS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
SPACE PLASMAS TELEMETRY TELEVISION CAMERAS
Language Note: English
Notes:
IN: Space structures, power, and power conditioning; Proceedings of the Meeting, Los Angeles, CA, Jan. 11-13, 1988 (A88-42547 17-20). Bellingham, WA, Society of Photo-Optical Instrumentation Engineers, 1988, p. 317-325.
Space structures, power, and power conditioning Los Angeles, CA Jan. 11-13, 1988

TITLE: ***Ionization-induced instability in an electron-collecting sheath***

Document ID: **19880060740** A (88A47967) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:

Cooke, David L. (USAF, Geophysics Laboratory, Hanscom AFB) Katz, Ira (Maxwell Laboratories, Inc.)

Journal Title: Journal of Spacecraft and Rockets **Volume**: 25 **Page**: 132-138
Published: Apr 01, 1988
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 7
Contract Number: None
NASA Subject Category: GEOPHYSICS
Abstract:

The space charge-limited regime suitable to objects whose characteristic size is much smaller than the ambient Debye length, and have a uniform surface potential much greater than the ambient plasma temperature, is presently investigated through the application of analytical and numerical methods to the electron-collecting sheath around a positively-biased probe in the ionosphere, in order to determine the effect of ionization within the sheath. Both analytical and computational results indicate that, when secondary ion production exceeds a critical level, the sheath edge propagates outward explosively, in a way similar to the propagation of double layers.

Major Subject Terms:
EARTH IONOSPHERE IONOSPHERIC SOUNDING MAGNETOHYDRODYNAMIC STABILITY PLASMA SHEATHS SPACECRAFT CHARGING
Minor Subject Terms:
COMPUTERIZED SIMULATION DEBYE LENGTH PLASMA TEMPERATURE SPACE CHARGE SPACE ENVIRONMENT SIMULATION
Language Note: English
Notes:

Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, March-Apr. 1988, p. 132-138.

TITLE: ***Electron collection by multiple objects within a single sheath***

Document ID: **19880067772** A (88A54999) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Davis, V. A. (Maxwell Labs., Inc.) Mandell, M. J. (Maxwell Labs., Inc.) Katz, I. (Maxwell Laboratories, Inc.)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 25 **Page**: 94
Published: Feb 01, 1988
Corporate Source:
Maxwell Labs., Inc. (La Jolla, CA, United States)
Pages: 2
Contract Number: NAS3-23881
NASA Subject Category: PLASMA PHYSICS
Abstract:
NASCAP/LEO, a computer program for the three-dimensional simulation of high-voltage surfaces with plasma, has been developed as a tool in the design of reliable, high-power spacecraft. NASCAP/LEO computes the potentials using analytic formulations for space charge, and only uses particle tracking to compute the current to the surfaces. Carruth's (1987) experimental results agree with the NASCAP/LEO simulations for the cases of both individual and overlapping sheaths.
Major Subject Terms:
PLASMA-ELECTROMAGNETIC INTERACTION SPACE PLASMAS SPACECRAFT CHARGING SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
CHARGE TRANSFER EARTH ORBITAL ENVIRONMENTS PLASMA TEMPERATURE SPACE CHARGE THREE DIMENSIONAL MODELS
Language Note: English
Notes:
Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, Jan.-Feb. 1988, p. 94, 95.
95

TITLE: ***POLAR 2.0 validation and preflight SPEAR I (Space Power Experiments Aboard Rockets) calculations***

Document ID: **19890008251** N (89N17622) **File Series**: NASA Technical Reports
Report Number: AD-A201094 • SSS-R-88-9311 • AFGL-TR-88-0056 • SR-7
Sales Agency & Price: CASI Hardcopy A03 • CASI Microfiche A01
Authors:
Jongeward, G. A. (Systems Science and Software) • Mandell, M. J. (Systems Science and Software) • Lilley, J. (Systems Science and Software) • Katz, I. (Systems Science and Software)
Published: Feb 01, 1988
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 36
Contract Number: F19668-86-C-0056
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The authors present a description of the POLAR 2.0 code and data structure. POLAR 2.0 calculations of the self-consistent magnetosheath of a sphere in a magnetic field are presented and shown to be consistent with the Parker-Murphy limits. The POLAR code is shown to agree with the results of a 2-dimensional code for this symmetric case. Preflight SPEAR II calculation of the current distribution to the spheres, booms, and rocket body were performed for two of the voltage configurations. These results are presented here and compared with corresponding nonself-consistent calculations using the NASCAP/LEO code.
Major Subject Terms:
AEROSPACE SYSTEMS • ELECTRIC POTENTIAL • MAGNETIC FIELD CONFIGURATIONS • PLASMA SHEATHS • SPACE CHARGE • SPACEBORNE EXPERIMENTS
Minor Subject Terms:
CODING • CONSISTENCY • DATA BASES • PROGRAM VERIFICATION (COMPUTERS) • SPHERES • SYMMETRY
Language Note: English

TITLE: ***Cross field transport of electrons: Implications for the POLAR code, spacecraft charging***

Document ID: **19890012456** N (89N21827) **File Series**: NASA Technical Reports
Report Number: AD-A204392 AFGL-TR-88-0127 AFGL-ERP-1003
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Cooke, David L. (Air Force Geophysics Lab.) Dubs, Charles (Air Force Geophysics Lab.) Heinemann, Michael (Air Force Geophysics Lab.)
Published: May 17, 1988
Corporate Source:
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 20
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Early studies of electron transport in crossed E and B fields have been reviewed and applied to the case of a positive surface moving in the ionosphere. That work points to the importance of the parameter q = omega p2/omega c2 in determining self consistent space charge distributions in cross field diodes, and similarly, a crossed field probe plasma sheath in non linear, non adiabatic limits. The application of existing theory to the problem of electron collection by a surface aligned with B indicates that for q greater than 1/2 the plasma sheath is only slightly perturbed by B, but for q less than 1/2 the sheath cannot form without electrons transported along B from the ends.
Major Subject Terms:
CROSSED FIELDS EARTH IONOSPHERE ELECTRONS PLASMA SHEATHS POLAR REGIONS
Minor Subject Terms:
CODING COLLECTION DIODES
Language Note: English

TITLE: ***Overview of environmental factors***

Document ID: **19890014158** N (89N23529) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A03
Authors:
Purvis, C. K. (NASA Lewis Research Center)
Journal Title: NASA, Langley Research Center, NASA(SDIO Space Environmental Effects on Materials Workshop, Part 1 **Page**: p 5-24
Published: May 01, 1989
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 20
Contract Number: None
NASA Subject Category: SPACE SCIENCES (GENERAL)
Abstract:
The orbital environment is complex, dynamic, and comprised of both natural and system-induced components. Several environment factors are important for materials. Materials selection/suitability determination requires consideration of each and all factors, including synergisms among them. Understanding and evaluating these effects will require ground testing, modeling, and focused flight experimentation.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS METEORITES RADIATION EFFECTS SPACE DEBRIS SPACE PLASMAS SPACECRAFT CONSTRUCTION MATERIALS
Minor Subject Terms:
CHARGED PARTICLES GENERAL OVERVIEWS NEUTRAL ATMOSPHERES PLASMA DENSITY SOLAR RADIATION TRAPPED PARTICLES
Language Note: English
Notes:
In NASA, Langley Research Center, NASA/SDIO Space Environmental Effects on Materials Workshop, Part 1 p 5-24 (SEE N89-23528 17-23)

TITLE: ***Surface phenomena in plasma environments***

Document ID: **19890014184** N (89N23555) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A03
Authors:
Purvis, C. K. (NASA Lewis Research Center) Ferguson, D. C. (NASA Lewis Research Center)
Journal Title: NASA, Langley Research Center, NASA(SDIO Space Environmental Effects on Materials Workshop, Part 2 **Page**: p 511-534
Published: May 01, 1989
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 24
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
Plasma interactions and their effects on materials depend on a number of factors, including the pre-existing environment, the properties of surface materials and the characteristics of the system. An additional dimension is the question of mission: some payloads may be much more sensitive to plasma interactions than others. As an example, a payload whose objective is to measure the ambient environment will be more sensitive to any effects than will a power system. Material specific effects include charging and its associated effects, which can result in short- and long-term damage. Selection of materials for a particular application requires consideration of all factors and assessment of effects due to all causes. Proper selection and suitability determination requires analysis to identify the actual environment combined with testing under exposure to single and combined environment factors.
Major Subject Terms:
GEOMAGNETISM PLASMA INTERACTIONS SPACE PLASMAS SPACECRAFT CHARGING SURFACE REACTIONS
Minor Subject Terms:
ELECTRIC ARCS PARTICLE MOTION PLASMA CURRENTS PLASMA SHEATHS SOLAR ARRAYS SPACECRAFT COMPONENTS SPACECRAFT ORBITS
Language Note: English
Notes:
In NASA, Langley Research Center, NASA/SDIO Space Environmental Effects on Materials Workshop, Part 2 p 511-534 (SEE N89-23547 17-23)

TITLE: ***High-voltage solar cell modules in simulated low-earth-orbit plasma***

Document ID: **19890023751** A (89A11122) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Thiemann, Heinz (Physikalisch Technische Studien GmbH), Bogus, Klaus-Peter (ESA)

Journal Title: Journal of Spacecraft and Rockets **Volume**: 25 **Page**: 278-285
Published: Aug 01, 1988
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 8
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The behavior of solar cell modules at high voltages in a surrounding simulated LEO plasma has been characterized over an applied voltage range from -700 to +500 V. Measurements were obtained in a large chamber under high vacuum using argon ions from a Kaufman source to generate a high-density plasma of up to 10 to the 6th/cu cm. The results suggest that secondary electrons contribute to the anomalous current increase noted at positive module voltages above 300 V. The surface potential on the coverglasses of the solar cells was shown to increase to high values only in the vicinity of the interconnectors.
Major Subject Terms:
LOW EARTH ORBITS PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS SPACE ENVIRONMENT SIMULATION SPACECRAFT MODULES
Minor Subject Terms:
ORBITAL SPACE TESTS SPACECRAFT EQUIPMENT
Language Note: English
Notes:
Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 25, July-Aug. 1988, p. 278-285.

TITLE: ***Spacecraft electrical power systems lessons learned***

Document ID: **19890028040** A (89A15411) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Gerson, Amy C. Reiss (Boeing Aerospace Co.)
Published: Jan 01, 1988
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 4
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
This paper presents results of a survey of space power systems experts from industry, government, and academia concerning solutions to power systems problems. The topics addressed include systems engineering, solar arrays, arcing and corona discharge, plasma interaction, solar array deployment, power electronics, batteries, and power distribution wiring. Problems and concerns are reviewed for program phases starting with design, through development, testing, and flight operations.
Major Subject Terms:
FAILURE ANALYSIS SPACECRAFT ELECTRONIC EQUIPMENT SPACECRAFT POWER SUPPLIES SYSTEMS ENGINEERING
Minor Subject Terms:
COMPONENT RELIABILITY ORBITAL LIFETIME SOLAR ARRAYS SPACECRAFT RELIABILITY
Language Note: English
Notes:
IN: 1988 IECEC; Proceedings of the Twenty-third Intersociety Energy Conversion Engineering Conference, Denver, CO, July 31-Aug. 5, 1988. Volume 3 (A89-15176 04-44). New York, American Society of Mechanical Engineers, 1988, p. 785-788.
1988 IECEC Denver, CO July 31-Aug. 5, 1988

TITLE: ***Circuit model of surface arcing***

Document ID: **19890029037** A (89A16408) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Robiscoe, R. T. Sui, Zhifeng (Montana State University)

Journal Title: Journal of Applied Physics **Volume**: 64 **Page**: 4364-437
Published: Nov 01, 1988
Corporate Source:

(Corporate Source(s) Not Available)

Pages: 11
Contract Number: None
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:

A simple circuit model for a flashover arc is constructed involving the discharge of a capacitor C through a series inductor L and a resistor R. The arc current assumes a very simple form over most of its dynamic range, and such measured arc quantities as total charge transport, pulse width, peak current, and rise time are easily calculated. Straightforward a priori estimates of C, L, and R values give calculated arc quantities in good agreement with observation, for both typical magnitudes and areal scaling. The effect on areal scaling of allowing the arc resistance R to 'switch' during the evoluion of the arc from a small value characteristic of the arc plasma to a large value characteristic of the dielectric surface is analyzed.

Major Subject Terms:

DIELECTRICS ELECTRIC ARCS ELECTRICAL FAULTS ELECTROMAGNETIC RADIATION PLASMA JETS SURFACE PROPERTIES

Minor Subject Terms:

EQUIVALENT CIRCUITS INDUCTANCE RESONANT FREQUENCIES

Language Note: English
Notes:

Journal of Applied Physics (ISSN 0021-8979), vol. 64, Nov. 1, 1988, p. 4364-4374. DOE-sponsored research.

DOE-sponsored research

TITLE: ***The dynamics of charged particles in the near wake of a very negatively charged body - Laboratory experiment and numerical simulation***

Document ID: **19890054342** A (89A41713) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Morgan, M. Alvin (Northeastern Univ.) Chan, Chung (Northeastern University) Cooke, David L. (USAF, Geophysics Laboratory, Hanscom AFB) Tautz, Maurice F. (Radex, Inc.)
Journal Title: IEEE Transactions on Plasma Science **Volume**: 17 **Page**: 220-227
Published: Apr 01, 1989
Corporate Source:
Northeastern Univ. (Boston, MA, United States)
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Radex, Inc. (Carlisle, MA, United States)
Pages: 8
Contract Number: F19628-85-K-0053
NASA Subject Category: PLASMA PHYSICS
Abstract:
A numerical simulation that is cylindrical in configuration space and three-dimensional in velocity space has been initiated to test a model for the near-wake dynamics of a very negatively charged body, with reference to the plasma environment around spacecraft. The simulation parameters were closely matched to those of a laboratory experiment so that the results can be compared directly. The laboratory study showed that the electrons and ions can display different temporal features in the filling-in of the wake; and that they can both be found within one body diameter of an object with a highly negative body potential. It was also found that the temperature of the electrons in the very near wake could be somewhat colder than the ambient value, suggesting the possibility of a filtering mechanism being operative there. The simulation results to date largely corroborate the density findings.
Major Subject Terms:
CHARGED PARTICLES DIGITAL SIMULATION ELECTRON DENSITY (CONCENTRATION) ION CURRENTS NEAR WAKES SPACE PLASMAS
Minor Subject Terms:
DEBYE LENGTH VLASOV EQUATIONS
Language Note: English
Notes:
IEEE Transactions on Plasma Science (ISSN 0093-3813), vol. 17, April 1989, p. 220-227.

TITLE: ***Passive current collection***

Document ID: **19890055979** A (89A43350) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Thompson, W. B. (California, University)
Published: Jan 01, 1988
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 10
Contract Number: None
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:
Current collection by a large positively charged collector in LEO is shown to be possible with a modest voltage penalty, a collector of 500 sq m providing about 10 amps. The collection process is complex and unusual: ions are reflected, and the ambient plasma seriously disturbed over a volume greater than 10 to the 6th cu m, while plasma instabilities play an essential role. Physical processes are discussed, and the qualitative features of the current-voltage characteristics displayed.
Major Subject Terms:
ACCUMULATORS EARTH ORBITAL ENVIRONMENTS ELECTRIC CURRENT MAGNETOHYDRODYNAMIC STABILITY SPACECRAFT CHARGING TETHERLINES
Minor Subject Terms:
EARTH MAGNETOSPHERE ELECTRIC CONDUCTORS ELECTRICAL RESISTIVITY SPACECRAFT POWER SUPPLIES
Language Note: English
Notes:
IN: Space tethers for science in the space station era; Proceedings of the Second International Conference, Venice, Italy, Oct. 4-8, 1987 (A89-43326 18-12). Bologna, Societa Italiana di Fisica, 1988, p. 186-195.
Intl. Conference on Space Tethers for Science in the Space Station Era Venice Oct. 4-8, 1987

TITLE: ***On the need for space tests of plasma contactors as electron collectors***

Document ID: **19890055985** A (89A43356) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Katz, Ira (Systems Science and Software) Davis, Victoria Ann (Systems Science and Software)
Published: Jan 01, 1988
Corporate Source:
Systems Science and Software (San Diego, CA, United States)
Pages: 4
Contract Number: NAS3-23881
NASA Subject Category: PLASMA PHYSICS
Abstract:
An analysis is presented of laboratory experiments that have shown that hollow plasma sources can provide low-impedance contact with a background plasma. In particular, some experiments show an report an 'ignited mode' of electron collection using plasma sources where almost an ampere was collected at a potential of 100 volts. The experimental results are compared with theoretical and computational models of plasma layers. Preliminary results indicate that the measured potential profiles and collected currents during the 'ignited mode' correspond to an increase in the background plasma thermal current of more than an order of magnitude. The results imply that the 'ignited mode' results are substantially impacted by the laboratory electron source and the tank size. Only experiments performed in space will be able to provide the correct boundary conditions for reliably testing high electron collection by plasma contactors.
Major Subject Terms:
HOLLOW CATHODES PLASMA ELECTRODES SPACE PLASMAS SPACECRAFT CHARGING TETHERLINES
Minor Subject Terms:
ELECTRON BEAMS FINITE ELEMENT METHOD PLASMA LAYERS SPACECRAFT POWER SUPPLIES
Language Note: English
Notes:
IN: Space tethers for science in the space station era; Proceedings of the Second International Conference, Venice, Italy, Oct. 4-8, 1987 (A89-43326 18-12). Bologna, Societa Italiana di Fisica, 1988, p. 241-244.
Intl. Conference on Space Tethers for Science in the Space Station Era Venice Oct. 4-8, 1987

TITLE: ***Interaction between a plasma flow and a highly biased solar array***

Document ID: **19890059344** A (89A46715) **File Series**: Open Literature
Report Number: AIAA PAPER 89-2272
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hastings, Daniel E. Cho, Mengu Chang, Patrick (MIT)
Published: Jul 01, 1989
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 12
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Magnetic forces have been incorporated into a two-dimensional particle-in-cell simulation of current collection in a solar cell interconnector in order to investigate the influence of magnetic fields on snapover, the anomalous increase in current collection found in highly biased solar arrays. Snapover is regulated by the ability of secondary electrons to escape the dielectric coverglasses and exit through the conductor, and the presence of a magnetic field is shown to inhibit this escape and increase the voltage required for snapover. Drag calculations are performed which take into account the effect of having the conductor surrounded by dielectrics, as well as the charging of the dielectric by electrons.
Major Subject Terms:
MAGNETOHYDRODYNAMIC FLOW PARTICLE IN CELL TECHNIQUE PLASMA INTERACTIONS SOLAR ARRAYS
Minor Subject Terms:
BIAS DIELECTRICS ELECTRICAL FAULTS MAGNETIC FLUX SPACECRAFT CONSTRUCTION MATERIALS
Language Note: English
Notes:
AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 25th, Monterey, CA, July 10-13, 1989. 12 p.

TITLE: ***LEO high voltage solar array arcing response model, continuation 5***

Document ID: **19900016102** N (90N25418) **File Series**: NASA Technical Reports
Report Number: NASA-CR-186505 NAS 1.26:186505
Sales Agency & Price: CASI Hardcopy A05 CASI Microfiche A01
Authors:
Metz, Roger N. (Colby Coll.)
Published: Apr 01, 1989
Corporate Source:
Colby Coll. (Waterville, ME, United States)
Pages: 89
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The modeling of the Debye Approximation electron sheaths in the edge and strip geometries was completed. Electrostatic potentials in these sheaths were compared to NASCAP/LEO solutions for similar geometries. Velocity fields, charge densities and particle fluxes to the biased surfaces were calculated for all cases. The major conclusion to be drawn from the comparisons of our Debye Approximation calculations with NASCAP-LEO output is that, where comparable biased structures can be defined and sufficient resolution obtained, these results are in general agreement. Numerical models for the Child-Langmuir, high-voltage electron sheaths in the edge and strip geometries were constructed. Electrostatic potentials were calculated for several cases in each of both geometries. Velocity fields and particle fluxes were calculated. The self-consistent solution process was carried through one cycle and output electrostatic potentials compared to NASCAP-type input potentials.
Major Subject Terms:
CHILD-LANGMUIR LAW ELECTROSTATICS HIGH VOLTAGES MATHEMATICAL MODELS SOLAR ARRAYS
Minor Subject Terms:
BIAS DENSITY (NUMBER/VOLUME) ELECTRIC CHARGE SHEATHS VELOCITY DISTRIBUTION
Language Note: English

TITLE: ***Interactions between the Space Station and the environment: A preliminary assessment of EMI***

Document ID: **19900016241** N (90N25557) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03   CASI Microfiche A06
Authors:
Murphy, G. B. (Jet Propulsion Lab., California Inst. of Tech.)   Garrett, Henry B. (Jet Propulsion Lab., California Inst. of Tech.)
Journal Title: NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989)   **Page**: p 493-507
Published: Mar 01, 1990
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 15
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
A review of the interactions between proposed Space Station systems/payloads and the environment that contribute to electromagnetic interference was performed. Seven prime sources of interference have been identified. These are: The Space Station power system; active experiments such as beam injection; ASTROMAG; ram and wake density gradients; pick up ions produced by vented or offgassed clouds; waves produced by current loops that include the plasma and structure; arcing from high voltage solar arrays (or possible ESD in polar orbit). This review indicates that: minimizing leakage current from the 20 kHz power system to the structure; keeping the surfaces of the Space Station structure, arrays, and radiators nonconducting; minimizing venting of payloads or systems to non-operational periods; careful placement of payloads sensitive to magnetic field perturbations or wake noise; and designing an operational timeline compatible with experiment requirement are the most effective means of minimizing the effects of this interference. High degrees of uncertainty exist in the estimates of magnitudes of gas emission induced EMI, radiation of 20 kHz and harmonics, ASTROMAG induced interference, and arc threshold/frequency of the solar array. These processes demand further attention so that mitigation efforts are properly calibrated.
Major Subject Terms:
ELECTROMAGNETIC INTERFERENCE   MAGNETIC FIELDS   PAYLOADS   PLASMAS (PHYSICS)   SOLAR ARRAYS   SPACE STATION POWER SUPPLIES   SPACE STATIONS
Minor Subject Terms:
BEAM INJECTION   CALIBRATING   ESTIMATES   HARMONICS   HIGH VOLTAGES   LEAKAGE   MAGNITUDE   PERTURBATION   POLAR ORBITS   SENSITIVITY   SPACE STATION STRUCTURES   SPECTROMETERS   SUPERCONDUCTING MAGNETS   VENTING
Language Note: English
Notes:
In NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) p 493-507 (SEE N90-25503 19-59)

TITLE: ***Solar array arcing in plasmas***

Document ID: **19900016242** N (90N25558) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A06
Authors:
Ferguson, Dale C. (NASA Lewis Research Center)
Journal Title: NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) **Page**: p 509-513
Published: Mar 01, 1990
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 5
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
Solar cells in space plasma conditions are known to arc into the plasma when the interconnects are at a negative potential of a few hundred volts, relative to plasma potential. For cells with silver-coated interconnects, a threshold voltage for arcing exists at about -230 V, as found in both ground and LEO experiments. The arc rate beyond the threshold voltage depends nearly linearly on plasma density, but has a strong power-law dependence on voltage, such that for small increments in operating voltage there is a large increment in arc rate. The arcs generate broadband radio interference and visible light. In ground tests, interconnects have been damaged by arcs in cells having insufficient isolation from a source of high current. Models for the arcs are highly dependent on the choice of interconnect conductor material exposed to the plasma and possibly on the geometry and choice of adjacent insulator material. Finally, new technology solar cells use copper for the cell interconnects, a material which may have a lower arcing threshold voltage than silver. It is expected, from ground tests of simulated solar cells, that any junction of conductor and insulator exposed to space plasma conditions will arc into the plasma at a few hundred volts negative potential, relative to the local plasma.
Major Subject Terms:
CONDUCTORS INSULATORS PLASMA POTENTIALS RADIO FREQUENCY INTERFERENCE SOLAR ARRAYS SOLAR CELLS SPACE PLASMAS
Minor Subject Terms:
BROADBAND COPPER ELECTRIC POTENTIAL GROUND TESTS HIGH CURRENT ISOLATION PLASMA DENSITY SILVER TECHNOLOGY UTILIZATION THRESHOLD VOLTAGE
Language Note: English
Notes:
In NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) p 509-513 (SEE N90-25503 19-59)

TITLE: ***Photovoltaic array space power plus diagnostics experiment***

Document ID: **19900016243** N (90N25559) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A06
Authors:
Guidice, Donald A. (Air Force Geophysics Lab.)
Journal Title: NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) **Page**: p 515-519
Published: Mar 01, 1990
Corporate Source:
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 5
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The objective of the Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) experiment is to measure the effects of the interaction of the low- to mid-altitude space environment on the performance of a diverse set of small solar-cell arrays (planar and concentrator, representative of present and future military technologies) under differing conditions of velocity-vector orientation and simulated (by biasing) high-voltage operation. Solar arrays to be tested include Si and GaAs planar arrays and several types of GaAs concentrator arrays. Diagnostics (a Langmuir probe and a pressure gauge) and a transient pulse monitor (to measure radiated and conducted EMI during arcing) will be used to determine the impact of the environment on array operation to help verify various interactions models. Results from a successful PASP Plus flight will furnish answers to important interactions questions and provide inputs for design and test standards for photovoltaic space-power subsystems.
Major Subject Terms:
AEROSPACE ENVIRONMENTS DIAGNOSIS MONITORS PHOTOVOLTAIC CELLS SOLAR ARRAYS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
BREADBOARD MODELS CONCENTRATORS ELECTROSTATIC PROBES FABRICATION GALLIUM ARSENIDES HIGH VOLTAGES SPACE FLIGHT
Language Note: English
Notes:
In NASA, Lyndon B. Johnson Space Center, Third Annual Workshop on Space Operations Automation and Robotics (SOAR 1989) p 515-519 (SEE N90-25503 19-59)

TITLE: ***Comparison of currents predicted by NASCAP/LEO model simulations with elementary Langmuir-type bare probe models for an insulated cable containing a single pinhole***

Document ID: **19900016738** N (90N26054) **File Series**: NASA Technical Reports
Report Number: NASA-TM-102486 • E-5095 • NAS 1.15:102486
Sales Agency & Price: CASI Hardcopy A03 • CASI Microfiche A01
Authors:
Galofaro, Joel T. (NASA Lewis Research Center)
Published: Jul 01, 1990
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 39
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The behavior of a defect in the insulation of a short biased section of cable in a Low Earth Orbit (LEO) space environment was examined. Such studies are of the utmost importance for large space power systems where great quantities of cabling will be deployed. An insulated probe containing a pinhole was placed into a hypothetical high speed LEO plasma. The NASA Charging Analyzer Program (NASCAP/LEO) was used to explore sheath growth about the probe as a function of applied voltage and to predict I-V behavior. A set of independent current calculations using Langmuir's formulations for concentric spheres and coaxial cylinders were also performed. The case of concentric spheres was here extended to include the case of concentric hemispheres. Several simple Langmuir-type models were then constructed to bracket the current collected by the cable. The space-charge sheath radius and impact parameters were used to determine the proper current regime. I-V curves were plotted for the models and comparisons were made with NASCAP/LEO results. Finally, NASCAP/LEO potential contours and surface cell potential plots were examined to explain interesting features in the NASCAP/LEO I-V curve.
Major Subject Terms:
AEROSPACE ENVIRONMENTS • DEFECTS • ELECTRIC POTENTIAL • INSULATION • PINHOLES • PLASMA SHEATHS • SIMULATION • SPACECRAFT CHARGING
Minor Subject Terms:
BIAS • BRACKETS • CONCENTRIC SPHERES • CONTOURS • DEPLOYMENT • EARTH ORBITS • HIGH SPEED • LARGE SPACE STRUCTURES • LOW EARTH ORBITS • SPACECRAFT POWER SUPPLIES
Language Note: English

TITLE: ***Recent observations of high voltage spacecraft-environment interaction at LEO altitudes using sounding rockets***

Document ID: **19900032904** A (90A19959) **File Series**: Open Literature
Report Number: AIAA PAPER 90-0635
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Raitt, W. J. (Utah State Univ.) Myers, N. B. (Utah State Univ.) Roberts, J. A. (Utah State Univ.) Thompson, D. C. (Utah State University) Gilchrist, B. E. (Stanford University)
Published: Jan 01, 1990
Corporate Source:
Utah State Univ. (Logan, UT, United States)
Stanford Univ. (CA, United States)
Pages: 8
Contract Number: DNA001-87-C-0015
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The paper addresses the subject of the interaction of positively and negatively charged bodies with the terrestrial ionosphere at low earth orbit altitudes. Data from two recent sounding rocket flights are used to establish that the current collected by exposed conductors biassed positively at up to 45kV relative to the ionospheric plasma generally follow predictions which account for strong control of electron flow by the geomagnetic field. If the biased structure is in the vicinity of disturbing influences such as an emitted charged particle beam, or locally enhanced gas pressure, then large deviations from the space-charge-limited return currents occur.
Major Subject Terms:
EARTH IONOSPHERE EARTH ORBITAL ENVIRONMENTS ELECTRON BEAMS HIGH VOLTAGES PLASMA INTERACTIONS SOUNDING ROCKETS
Minor Subject Terms:
CIRCUITS LOW EARTH ORBITS SPACE PLATFORMS SPACEBORNE EXPERIMENTS VOLT-AMPERE CHARACTERISTICS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 8 p.

TITLE: ***Dielectric charging processes and arcing rates of high voltage solar array***

Document ID: **19910034758** A (91A19381) **File Series**: Open Literature
Report Number: AIAA PAPER 91-0605
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Cho, Mengu   Hastings, Daniel E. (MIT)

Published: Jan 01, 1991
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 11
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
When high voltage solar arrays are used in the LEO environment, serious interactions are known to occur between the solar cell material and the surrounding plasmas. Arcing is known to be the most severe interaction. The charging process of the dielectric coverglass by charged particles is studied numerically. If there is a field emission site with a high electric field enhancement factor beta on the interconnector, charging process due to enhanced field electron emission can be initiated and leads to the Townsend breakdown in the neutral gas desorbed from the coverglass. Based on this arcing onset model, the arcing rate is calculated taking the reciprocal of the charging time and the threshold voltage is found to be a few hundred volts negative independent of the ambient ion density.
Major Subject Terms:
ARC DISCHARGES   EARTH ORBITAL ENVIRONMENTS   ELECTRIC CHARGE   HIGH VOLTAGES   SOLAR ARRAYS   SPACE PLASMAS
Minor Subject Terms:
CHARGED PARTICLES   SOLAR CELLS   TECHNOLOGICAL FORECASTING
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p.

TITLE: ***The Space Station photovoltaic panels plasma interaction test program - Test plan and results***

Document ID: **19900035197** A (90A22252) **File Series**: Open Literature
Report Number: AIAA PAPER 90-0722
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Nahra, Henry K. (NASA Lewis Research Center) Felder, Marian C. (NASA Lewis Research Center) Sater, Bernard L. (NASA Lewis Research Center) Staskus, John V. (NASA Lewis Research Center)

Published: Jan 01, 1990
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 11
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

The plasma Interaction Test performed on two space station solar array panels is addressed. This includes a discussion of the test requirements, test plan, experimental set-up, and test results. It was found that parasitic current collection was insignificant (0.3 percent of the solar array delivered power). The measured arcing threshold ranged from -210 to -457 V with respect to the plasma potential. Furthermore, the dynamic response of the panels showed the panel time constant to range between 1 and 5 microsec, and the panel capacitance to be between .01 and .02 microF.

Major Subject Terms:

PANELS PLASMA CURRENTS PLASMA INTERACTIONS SOLAR ARRAYS SPACE STATION POWER SUPPLIES

Minor Subject Terms:

ARC DISCHARGES DYNAMIC RESPONSE PERFORMANCE TESTS PLASMA DENSITY USER REQUIREMENTS

Language Note: English
Notes:

AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 11 p. Previously announced in STAR as N90-13581.

TITLE: ***High-voltage plasma interactions calculations using NASCAP/LEO***

Document ID: **19900035199** A (90A22254) **File Series**: Open Literature
Report Number: AIAA PAPER 90-0725
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Mandell, M. J. (Systems Science and Software) Katz, I. (Systems Science and Software)
Published: Jan 01, 1990
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 16
Contract Number: NAS3-23881
NASA Subject Category: PLASMA PHYSICS
Abstract:
This paper reviews four previous simulations (two laboratory and two space-flight) of interactions of a high-voltage spacecraft with a plasma under low-earth orbit conditions, performed using a three-dimensional computer code NASCAP/LEO. Results show that NASCAP/LEO can perform meaningful simulations of high-voltage plasma interactions taking into account three-dimensional effects of geometry, spacecraft motion, and magnetic field. Two new calculations are presented: (1) for current collection by 1-mm pinholes in wires (showing that a pinhole in a wire can collect far more current than a similar pinhole in a flat plate); and (2) current collection by Charge-2 mother vehicle launched in December 1985. It is shown that the Charge-2 calculations predicted successfully ion collection at negative bias, the floating potential of a probe outside or inside the sheath under negative bias conditions, and magnetically limited electron collection under electron beam operation at high altitude.
Major Subject Terms:
COMPUTERIZED SIMULATION EARTH ORBITAL ENVIRONMENTS HIGH VOLTAGES PLASMA INTERACTIONS SPACECRAFT CHARGING
Minor Subject Terms:
COMPUTATIONAL GRIDS CONJUGATE GRADIENT METHOD ELECTROSTATIC CHARGE FINITE ELEMENT METHOD LOW EARTH ORBITS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 16 p.

TITLE: ***Plasma contactor modeling with NASCAP/LEO - Extending laboratory results to space systems***

Document ID: **19900035200** A (90A22255) **File Series**: Open Literature
Report Number: AIAA PAPER 90-0726
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Davis, V. A. (Systems Science and Software) Katz, I. (Systems Science and Software) Mandell, M. J. (Systems Science and Software)
Published: Jan 01, 1990
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 6
Contract Number: NAS3-23881
NASA Subject Category: PLASMA PHYSICS
Abstract:
In the laboratory, hollow cathode-based plasma contactors have been observed to both emit and collect ampere-level electron currents with low impedance. The laboratory behavior of hollow cathode-based plasma contactors and the limited space experience with hollow cathodes suggest that, for many applications, a hollow cathode-based plasma contactor is the ideal device to provide electrical connection with the space plasma. In order to confidently extend the laboratory experience to the low-earth-orbit environment, a series of plasma contactor computer models has been developed. Calculations show that a hollow cathode plasma contactor that collects 0.5 A in the laboratory will only collect 2.4 mA in space. The simplest way to boost the collected current is to increase the gas flow. A mole of gas is enough to collect ampere level currents for 5-1/2 hours.
Major Subject Terms:
COMPUTERIZED SIMULATION HOLLOW CATHODES PLASMA ELECTRODES SPACE ENVIRONMENT SIMULATION SPACE PLASMAS
Minor Subject Terms:
COMPUTATIONAL GRIDS EARTH ORBITAL ENVIRONMENTS ELECTRON DENSITY (CONCENTRATION) GAS FLOW LOW EARTH ORBITS PLASMA CURRENTS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 28th, Reno, NV, Jan. 8-11, 1990. 6 p.

TITLE: ***Computer modeling of current collection by the CHARGE-2 mother payload***

Document ID: **19900037878** A (90A24933) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Mandell, M. J. (Maxwell Labs., Inc.) Lilley, J. R., Jr. (Maxwell Labs., Inc.) Katz, I. (Maxwell Laboratories, Inc.) Neubert, T. (Stanford University) Myers, Neil B. (Utah State University)
Journal Title: Geophysical Research Letters **Volume**: 17 **Page**: 135-138
Published: Feb 01, 1990
Corporate Source:
Maxwell Labs., Inc. (San Diego, CA, United States)
Stanford Univ. (CA, United States)
Utah State Univ. (Logan, UT, United States)
Pages: 4
Contract Number: NAS3-23881 F19628-86-C-0056
NASA Subject Category: PLASMA PHYSICS
Abstract:
The three-dimensional computer codes NASCAP/LEO and POLAR have been used to calculate current collection by the mother payload of the CHARGE-2 rocket under conditions of positive and negative potential up to several hundred volts. For negative bias (ion collection), the calculations lie about 25 percent above the data, indicating that the ions were less dense, colder, or heavier than the input parameters. For positive bias (electron collection), NASCAP/LEO and POLAR calculations show similar agreement with the measurements at the highest altitudes. This agreement indicates that the current is classically magnetically limited, even during electron beam emission. However, the calculated values fall well below the data at lower altitudes. It is suggested that beam-plasma-neutral interactions are responsible for the high values of collected current at altitudes below 240 km.
Major Subject Terms:
COMPUTERIZED SIMULATION GEOMAGNETISM MAGNETOSPHERIC ELECTRON DENSITY MAGNETOSPHERIC ION DENSITY PAYLOADS ROCKET SOUNDING
Minor Subject Terms:
EARTH ORBITAL ENVIRONMENTS FINITE ELEMENT METHOD MAGNETOSHEATH TETHERING
Language Note: English
Notes:
Geophysical Research Letters (ISSN 0094-8276), vol. 17, Feb. 1990, p. 135-138.

TITLE: ***Ion drag for a negatively biased solar array in low earth orbit***

Document ID: **19900049136** A (90A36191) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hastings, Daniel E. (Massachusetts Inst. of Tech.) • Cho, Mengu (MIT)
Journal Title: Journal of Spacecraft and Rockets • **Volume**: 27 **Page**: 279-284
Published: Jun 01, 1990
Corporate Source:
Massachusetts Inst. of Tech. (Cambridge, MA, United States)
Pages: 6
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Highly biased solar arrays in the space environment are found to have a number of significant interactions with the space environment. The enhanced drag suffered by highly biased solar arrays is studied with the particle-in-cell code. The results are compared to recent numerical work. The drag calculations contain the effect of having the conductor surrounded by dielectrics as well as the charging of the dielectric by electrons. The results are used to calculate the attitude change expected on the high-voltage solar array of the Japanese Space Flyer Unit.
Major Subject Terms:
DRAG COEFFICIENTS • EARTH ORBITAL ENVIRONMENTS • ION DENSITY (CONCENTRATION) • LOW EARTH ORBITS • RESPONSE BIAS • SOLAR ARRAYS
Minor Subject Terms:
ATTITUDE STABILITY • JAPANESE SPACE PROGRAM • PARTICLE IN CELL TECHNIQUE
Language Note: English
Notes:
Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, May-June 1990, p. 279-284.

TITLE: ***Development and testing of a 20 kHz component test bed***

Document ID: 19900051071 A (90A38126) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Button, Robert M. (NASA Lewis Research Center) Brush, Andrew S. (NASA Lewis Research Center) Sundberg, Richard C. (General Dynamics Corp.)

Published: Jan 01, 1989
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)
Sverdrup Technology, Inc. (Middleburg Heights, OH, United States)
General Dynamics Corp. (San Diego, CA, United States)

Pages: 6
Contract Number: NAS3-25266
NASA Subject Category: GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)
Abstract:

A history of the General Dynamics Space Systems Division 20-kHz breadboard is presented, including its current configuration and its role in the SSF program. Highlights and results are presented of a series of tests conducted on the 20 kHz breadboard. The first test presented is the 20 kHz Breadboard Acceptance test. This test verified the operation of the delivered Breadboard and also characterized the main components of the system. Next, an in-depth efficiency testing effort is presented. The tests attempted to apportion all the power losses in the 20 Hz Breadboard Main Inverter Units. Distortion test data are presented, showing the distortion characteristics of a Mapham inverter. Lastly, current work on the 20 kHz Breadboard is presented including Main Inverter Unit paralleling tests. Conclusions are summarized and references given.

Major Subject Terms:

BREADBOARD MODELS PERFORMANCE TESTS SPACE STATIONS SPACECRAFT POWER SUPPLIES

Minor Subject Terms:

CONTROLLERS INVERTERS POWER EFFICIENCY POWER LINES PROVING REMOTE CONTROL SEMICONDUCTOR DEVICES TRADEOFFS TRANSFORMERS

Language Note: English
Notes:

IN: IECEC-89; Proceedings of the Twenty-fourth Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 6-11, 1989. Volume 1 (A90-38029 16-20). New York, Institute of Electrical and Electronics Engineers, 1989, p. 605-610. Previously announced in STAR as N89-25403.

IECEC-89 Washington, DC Aug. 6-11, 1989

TITLE: ***Compatibility of large space based power systems with environmental sensors***

Document ID: **19900051214** A (90A38269) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Murphy, G. (Jet Propulsion Lab., California Inst. of Tech.) Garrett, H. (JPL)
Published: Jan 01, 1989
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 10
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
A methodology is presented for reviewing various interactions between power systems and the environment that affect the longevity, calibration, maintenance, and accuracy of sensors. The analysis uses the low-earth-orbit environment and interactions with the space station power system as a case study in system compatibility. Space-based power systems and sensor systems are described, compatibility modeling is discussed, and the analysis of the space station case is presented. Steps to be taken during design to promote compatibility are outlined.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ENVIRONMENTAL MONITORING SENSORS SPACE STATION POWER SUPPLIES SYSTEMS COMPATIBILITY
Minor Subject Terms:
ALTERNATING CURRENT GLOW DISCHARGES HIGH VOLTAGES LOW EARTH ORBITS MAGNETOHYDRODYNAMIC WAVES PHOTOVOLTAIC EFFECT SPACE PLASMAS TRANSMISSION LINES
Language Note: English
Notes:
IN: IECEC-89; Proceedings of the Twenty-fourth Intersociety Energy Conversion Engineering Conference, Washington, DC, Aug. 6-11, 1989. Volume 6 (A90-38029 16-20). New York, Institute of Electrical and Electronics Engineers, 1989, p. 2631-2640.
IECEC-89 Washington, DC Aug. 6-11, 1989

TITLE: ***Plasma sources for spacecraft neutralization***

Document ID: **19900051642** A (90A38697) **File Series**: Open Literature
Report Number: AIAA PAPER 90-1556
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Davis, V. A. (Systems Science and Software) Katz, I. (Systems Science and Software) Mandell, M. J. (Systems Science and Software)
Published: Jun 01, 1990
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 12
Contract Number: NAS3-23881
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The principles of the operation of plasma sources for the neutralization of the surface of a spacecraft traveling in the presence of hot plasma are discussed with special attention given to the hollow-cathode-based plasma contactors. Techiques are developed that allow the calculation of the potentials and particle densities in the near environment of a hollow cathode plasma contactor in both the test tank and the LEO environment. The techniques and codes were validated by comparison of calculated and measured results.
Major Subject Terms:
BEAM NEUTRALIZATION HIGH TEMPERATURE PLASMAS PLASMA-PARTICLE INTERACTIONS SPACECRAFT CHARGING
Minor Subject Terms:
EARTH ORBITAL ENVIRONMENTS HOLLOW CATHODES PLASMA DENSITY VOLT-AMPERE CHARACTERISTICS
Language Note: English
Notes:
AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 21st, Seattle, WA, June 18-20, 1990. 12 p.

TITLE: ***Physical processes associated with current collection by plasma contactors***

Document ID: **19910008409** N (91N17722) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A03
Authors:
Katz, Ira (Systems Science and Software) Davis, Victoria A. (Systems Science and Software)
Journal Title: NASA, Marshall Space Flight Center, Current Collection from Space Plasmas **Page**: p 190-200
Published: Dec 01, 1990
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 11
Contract Number: NAS3-23881
NASA Subject Category: PLASMA PHYSICS
Abstract:
Recent flight data confirms laboratory observations that the release of neutral gas increases plasma sheath currents. Plasma contactors are devices which release a partially ionized gas in order to enhance the current flow between a spacecraft and the space plasma. Ionization of the expellant gas and the formation of a double layer between the anode plasma and the space plasma are the dominant physical processes. A theory is presented of the interaction between the contactor plasma and the background plasma. The conditions for formation of a double layer between the two plasmas are derived. Double layer formation is shown to be a consequence of the nonlinear response of the plasmas to changes in potential. Numerical calculations based upon this model are compared with laboratory measurements of current collection by hollow cathode-based plasma contactors.
Major Subject Terms:
CONTACTORS EXPELLANTS GAS IONIZATION PLASMA PHYSICS PLASMA SHEATHS PLASMAS (PHYSICS) SPACE CHARGE SPACE PLASMAS
Minor Subject Terms:
ANODES NEUTRAL GASES NONLINEARITY
Language Note: English
Notes:
In NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 190-200 (SEE N91-17713 09-75)

TITLE: ***Double layers in contactor plasmas***

Document ID: **19910008410** N (91N17723) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:

Cooke, David L. (Air Force Geophysics Lab.)

Journal Title: NASA, Marshall Space Flight Center, Current Collection from Space Plasmas **Page**: p 201
Published: Dec 01, 1990
Corporate Source:

Air Force Geophysics Lab. (Hanscom AFB, MA, United States)

Pages: 1
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:

The concept of using a hollow cathode to establish a low impedance contact between a spacecraft and the ambient plasma continues to gain in popularity, and is often then referred to as a plasma contactor. A growing number of studies indicate that large contact currents can be supported with small potential difference between the contactor and the ambient plasma. Results will be presented from a simple one-dimensional spherical model that obtains potentials from the solution of Poisson's equation, and particle densities from a turning point formalism that includes particle angular momentum. The neglect of collisions and magnetic field limits the realism. However, the results illustrate the effect of double layers that can form at the interface between contactor and ambient plasmas, when there is any voltage differential between the contactor and the ambient. The I-V characteristic of this model shows the usual space charge depends upon collection when the contactor flux is lower than some threshold; independence of I from variation in V when the flux is slightly greater than that threshold, and (numerical ?) instability for excessive flux suggesting the possibility of negative resistance. Even if a real I-V characteristic does not exhibit negative resistance, flat spots or high resistance regions may still be troublesome (or useful) to the total circuit.

Major Subject Terms:

CONTACTORS HOLLOW CATHODES MAGNETIC FIELDS MATHEMATICAL MODELS PLASMA LAYERS PLASMA PROBES PLASMAS (PHYSICS) SPACE CHARGE SPACE PLASMAS

Minor Subject Terms:

ANGULAR MOMENTUM CIRCUITS COLLISIONS ELECTRIC POTENTIAL FORMALISM IMPEDANCE POISSON EQUATION

Language Note: English
Notes:

In NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 201 (SEE N91-17713 09-75)

TITLE: ***NASCAP/LEO calculations of current collection***

Document ID: **19910008420** N (91N17733) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A03
Authors:
Mandell, Myron J. (Systems Science and Software) Katz, Ira (Systems Science and Software) Davis, Victoria A. (Systems Science and Software) Kuharski, Robert A. (Systems Science and Software)
Journal Title: NASA, Marshall Space Flight Center, Current Collection from Space Plasmas **Page**: p 334-351
Published: Dec 01, 1990
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 18
Contract Number: NAS3-23881
NASA Subject Category: PLASMA PHYSICS
Abstract:
NASCAP/LEO is a 3-dimensional computer code for calculating the interaction of a high-voltage spacecraft with the cold dense plasma found in Low Earth Orbit. Although based on a cubic grid structure, NASCAP/LEO accepts object definition input from standard computer aided design (CAD) programs so that a model may be correctly proportioned and important features resolved. The potential around the model is calculated by solving the finite element formulation of Poisson's equation with an analytic space charge function. Five previously published NASCAP/LEO calculations for three ground test experiments and two space flight experiments are presented. The three ground test experiments are a large simulated panel, a simulated pinhole, and a 2-slit experiment with overlapping sheaths. The two space flight experiments are a solar panel biased up to 1000 volts, and a rocket-mounted sphere biased up to 46 kilovolts. In all cases, the authors find good agreement between calculation and measurement.
Major Subject Terms:
COLD PLASMAS COMPUTER PROGRAMS EARTH ORBITS HIGH VOLTAGES SOLAR CELLS SPACE CHARGE SPACEBORNE EXPERIMENTS SPACECRAFT CHARGING SPHERES
Minor Subject Terms:
ANALYTIC FUNCTIONS BIAS COMPUTER AIDED DESIGN DENSE PLASMAS FINITE ELEMENT METHOD GROUND TESTS LOW EARTH ORBITS PINHOLES POISSON EQUATION
Language Note: English
Notes:
In NASA, Marshall Space Flight Center, Current Collection from Space Plasmas p 334-351 (SEE N91-17713 09-75)

TITLE: ***High voltage plasma sheath analysis related to TSS-1***

Document ID: **19910009696** N (91N19009) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A03
Authors:
Sheldon, John W. (Florida International Univ.)
Journal Title: Alabama Univ., Research Reports: 1990 NASA(ASEE Summer Faculty Fellowship Program **Page**: 4 p
Published: Oct 01, 1990
Corporate Source:
Florida International Univ. (Miami, FL, United States)
Pages: 4
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
On the first mission of the Tethered Satellite System (TSS-1), a 1.8 m diameter spherical satellite will be deployed a distance of 20 km above the Space Shuttle Orbiter on an insulated conducting tether. The satellite will be held at electric potentials up to 5000 volts positive with respect to the ambient plasma. Due to the passage of the conducting tether through the Earth's magnetic field, an electromagnetic field (EMF) will be created, driving electrons down the tether to the Orbiter, out through an electron gun into the ionosphere and back into the positive-biased satellite. The main problem addressed here is the current-voltage characteristics of the ionospheric interaction with the satellite. The first problem is that while the satellite will be capable of measuring charged particle flow to the surface at several locations, the detectors have a limited range of acceptance angle. The second problem is that the angle of incidence of the incoming electrons will have to be relative to the local normal. This will be important in order to predict the magnitude of the detectable current at each detector location so the detector gain can be pre-set to the correct range. The plasma sheath was analyzed mathematically, and subroutines were written to solve relevant finite element, Taylor-Vlasov, and Poisson equations.
Major Subject Terms:
ELECTROMAGNETIC FIELDS ELECTRONS HIGH VOLTAGES PLASMA PHYSICS PLASMA SHEATHS SPACE PLASMAS SPACE SHUTTLE ORBITERS TETHERED SATELLITES
Minor Subject Terms:
ANGLES (GEOMETRY) DEPLOYMENT DISTANCE ELECTRON GUNS FINITE ELEMENT METHOD GEOMAGNETISM INCIDENCE NASA PROGRAMS POISSON EQUATION POSITION (LOCATION) SUBROUTINES UNIVERSITY PROGRAM
Language Note: English
Notes:
In Alabama Univ., Research Reports: 1990 NASA/ASEE Summer Faculty Fellowship Program 4 p (SEE N91-18967 10-99)

TITLE: ***Findings of the Joint Workshop on Evaluation of Impacts of Space Station Freedom Ground Configurations***

Document ID: **19910011415** N (91N20728) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A03
Authors:
Ferguson, Dale C. (NASA Lewis Research Center) Snyder, David B. (NASA Lewis Research Center) Carruth, Ralph (NASA Marshall Space Flight Center)
Journal Title: NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) **Page**: p 689-694
Published: Jan 01, 1991
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
At the workshop, experts from the plasma interactions community evaluated the impacts of environmental interactions on the Space Station Freedom (SSF) under each of the proposed grounding schemes. The grounding scheme chosen for the SSF power system was found to have serious implications for SSF design. Interactions of the SSF power system and structure with the low Earth orbit (LEO) plasma differ significantly between different proposed grounding schemes. Environmental constraints will require modification of current SSF designs under any grounding scheme. Maintaining the present negative-grounding scheme compromises SSF safety, structural integrity, and electromagnetic compatibility. It also will increase contamination rates over alternative grounding schemes. One alternative, positive grounding of the array, requires redesign of the primary power system in work package four. Floating the array reduces the number of circuit changes to work package four but adds new hardware. Maintaining the current design will affect all work packages; however, no impacts were identified on work packages one, two, or three by positively grounding or floating the array, with the possible exception of extra corona protection in multi-wire connectors.
Major Subject Terms:
AEROSPACE SAFETY ELECTRICAL GROUNDING PLASMA INTERACTIONS SPACE STATION FREEDOM SPACE STATIONS SPACECRAFT CONFIGURATIONS SPACECRAFT DESIGN SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
ELECTROMAGNETIC COMPATIBILITY LOW EARTH ORBITS SPACECRAFT CONTAMINATION SPACECRAFT RELIABILITY STRUCTURAL RELIABILITY
Language Note: English
Notes:
In NASA, Lyndon B. Johnson Space Center, Fourth Annual Workshop on Space Operations Applications and Research (SOAR 90) p 689-694 (SEE N91-20702 12-59)

TITLE: ***Findings of the Joint Workshop on Evaluation of Impacts of Space Station Freedom Ground Configurations***

Document ID: **19910013057** N (91N22370) **File Series**: NASA Technical Reports
Report Number: NASA-TM-103717 E-5950 NAS 1.15:103717
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A01
Authors:
Ferguson, Dale C. (NASA Lewis Research Center) Snyder, David B. (NASA Lewis Research Center) Carruth, Ralph (NASA Marshall Space Flight Center)
Published: Jan 01, 1990
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 9
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
A workshop to consider the effects of various proposed Space Station Freedom (SSF) grounding schemes was held. Expert from the plasma interactions community evaluated the impacts of environmental interactions on SSF under each of three proposed grounding schemes. The choice of the grounding scheme for the SSF power system was found to have important implications for SSF design. Interactions of the SSF power system and structure with the low earth orbit (LEO) plasma differ significantly between different grounding schemes. Environmental constraints will require modification of current SSF designs under any grounding scheme. Maintaining the present negative ground scheme may compromise SSF safety, structural integrity, and electromagnetic compatibility, and will increase contamination rates over alternate schemes. Positive grounding of the array requires redesign of the primary power system. Floating the array reduces the number of circuit changes in the primary power system but adds new hardware. Maintaining the present design will affect all parts of SSF. However, no impacts were identified on SSF systems outside of the electrical power system by positively grounding or floating the array.
Major Subject Terms:
AEROSPACE ENVIRONMENTS CONFERENCES ELECTRICAL GROUNDING PLASMA INTERACTIONS SPACE STATION FREEDOM SPACE STATIONS
Minor Subject Terms:
CONTAMINATION EARTH ORBITS ELECTROMAGNETIC COMPATIBILITY LOW EARTH ORBITS PLASMAS (PHYSICS) SAFETY STRUCTURAL FAILURE
Language Note: English
Notes:
Presented at the Space Environment Analysis Workshop, Noordwijk, Netherlands, 9-12 Oct. 1990; sponsored by ESA
Space Environment Analysis Workshop Noordwijk 9-12 Oct. 1990

TITLE: ***Significant reduction in arc frequency biased solar cells: Observations, diagnostics, and mitigation technique(s)***

Document ID: **19910020921** N (91N30235) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:

Upschulte, B. L. (Physical Sciences, Inc., Andover) Weyl, G. M. (Physical Sciences, Inc., Andover) Marinelli, W. J. (Physical Sciences, Inc., Andover) Aifer, E. (Boston Univ.) Hastings, D. (Massachusetts Inst. of Tech.) Snyder, D. (NASA Lewis Research Center)

Journal Title: Space Photovoltaic Research and Technology Conference **Page**: 10 p
Published: Aug 01, 1991
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 10
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

A variety of experiments were performed which identify key factors contributing to the arcing of negatively biased high voltage solar cells. These efforts have led to reduction of greater than a factor of 100 in the arc frequency of a single cell following proper remediation procedures. Experiments naturally lead to and focussed on the adhesive/encapsulant that is used to bond the protective cover slip to the solar cell. An image-intensified charge coupled device (CCD) camera system recorded UV emission from arc events which occurred exclusively along the interfacial edge between the cover slip and the solar cell. Microscopic inspection of this interfacial region showed a bead of encapsulant along this entire edge. Elimination of this encapsulant bead reduced the arc frequency by two orders of magnitude. Water contamination was also identified as a key contributor which enhances arcing of the encapsulant bead along the solar cell edge. Spectrally resolved measurements of the observable UV light shows a feature assignable to OH(A-X) electronic emission, which is common for water contaminated discharges. Experiments in which the solar cell temperature was raised to 85 C showed a reduced arcing frequency, suggesting desorption of H2O. Exposing the solar cell to water vapor was shown to increase the arcing frequency. Clean dry gases such as O2, N2, and Ar show no enhancement of the arcing rate. Elimination of the exposed encapsulant eliminates any measurable sensitivity to H2O vapor.

Major Subject Terms:
ADHESIVES ARC DISCHARGES CONTAMINATION FREQUENCY RESPONSE HIGH VOLTAGES SOLAR CELLS WATER VAPOR
Minor Subject Terms:
BEADS ENCAPSULATING ULTRAVIOLET RADIATION
Language Note: English
Notes:
In its Space Photovoltaic Research and Technology Conference 10 p (SEE N91-30203 22-20)

TITLE: ***Measurement of high-voltage and radiation-damage limitations to advanced solar array performance***

Document ID: **19910020922** N (91N30236) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:
Guidice, D. A. (Phillips Lab.) Severance, P. S. (Phillips Lab.) Keinhardt, K. C. (Aeronautical Systems Div.)
Journal Title: NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference
Page: 10 p
Published: Aug 01, 1991
Corporate Source:
Air Force Geophysics Lab. (Hanscom AFB, MA, United States)
Pages: 10
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
A description is given of the reconfigured Photovoltaic Array Space Power (PASP) Plus experiment: its objectives, solar-array complement, and diagnostic sensors. Results from a successful spaceflight will lead to a better understanding of high-voltage and radiation-damage limitations in the operation of new-technology solar arrays.
Major Subject Terms:
HIGH VOLTAGES RADIATION DAMAGE RADIATION TOLERANCE SOLAR ARRAYS SOLAR CELLS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
ARTIFICIAL SATELLITES PERFORMANCE TESTS PLASMA INTERACTIONS SPACE PLASMAS
Language Note: English
Notes:
In NASA. Lewis Research Center, Space Photovoltaic Research and Technology Conference 10 p (SEE N91-30203 22-20)

TITLE: ***Leo space plasma interactions***

Document ID: **19910020935** N (91N30249) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A04
Authors:
Ferguson, Dale C. (NASA Lewis Research Center)
Journal Title: Space Photovoltaic Research and Technology Conference **Page**: 11 p
Published: Aug 01, 1991
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 11
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Photovoltaic arrays interact with the low earth orbit (LEO) space plasma in two fundamentally different ways. One way is the steady collection of current from the plasma onto exposed conductors and semiconductors. The relative currents collected by different parts of the array will then determine the floating potential of the spacecraft. In addition, these steady state collected currents may lead to sputtering or heating of the array by the ions or electrons collected, respectively. The second kind of interaction is the short time scale arc into the space plasma, which may deplete the array and/or spacecraft of stored charge, damage solar cells, and produce EMI. Such arcs only occur at high negative potentials relative to the space plasma potential, and depend on the steady state ion currents being collected. New high voltage solar arrays being incorporated into advanced spacecraft and space platforms may be endangered by these plasma interactions. Recent advances in laboratory testing and current collection modeling promise the capability of controlling, and perhaps even using, these space plasma interactions to enable design of reliable high voltage space power systems. Some of the new results may have an impact on solar cell spacing and/or coverslide design. Planned space flight experiments are necessary to confirm the models of high voltage solar array plasma interactions. Finally, computerized, integrated plasma interactions design tools are being constructed to place plasma interactions models into the hands of the spacecraft designer.
Major Subject Terms:
EARTH ORBITS PLASMA CONDUCTIVITY PLASMA INTERACTION EXPERIMENT PLASMA INTERACTIONS PLASMA POTENTIALS RADIATION DAMAGE SEMICONDUCTORS (MATERIALS) SOLAR ARRAYS SPACE PLASMAS SPACE PLATFORMS SPACEBORNE EXPERIMENTS SPACECRAFT POWER SUPPLIES SPUTTERING
Minor Subject Terms:
COMPUTER AIDED DESIGN ELECTRONS HEATING HIGH VOLTAGES IONS LOW EARTH ORBITS SPACING STEADY STATE
Language Note: English
Notes:
In its Space Photovoltaic Research and Technology Conference 11 p (SEE N91-30203 22-20)

TITLE: ***Role of current driven instabilities in the operation of plasma contactors used with electrodynamic tethers***

Document ID: **19910025710** A (91A10333) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Gioulekas, A. (Massachusetts Inst. of Tech.) Hastings, D. E. (MIT)
Journal Title: Journal of Propulsion and Power **Volume**: 6 **Page**: 559-566
Published: Oct 01, 1990
Corporate Source:
Massachusetts Inst. of Tech. (Cambridge, MA, United States)
Pages: 8
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
The collection of current to an electrodynamic tether in low LEO is enhanced by a plasma cloud surrounding the anode (called a plasma contactor). The main mechanism by which this is achieved is the scattering, perpendicular to the lines of the magnetic field, of the electrons which enter the plasma cloud. The scattering may be a result of the interaction between the electrons and unstable EM waves, one example being lower-hybrid waves. The boundaries of instability are found for the lower-hybrid waves in a parametric study where, for the cases of Ar and NH3 clouds, the density, the ratio of electron to ion temperature, and the composition of the electron population, are varied. The main conclusion is that the lower-hybrid waves will be confined to the outer regions of the cloud and have the right properties to scatter electrons.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRODYNAMICS MAGNETOHYDRODYNAMIC STABILITY PLASMA POWER SOURCES PLASMA-ELECTROMAGNETIC INTERACTION TETHERED SATELLITES
Minor Subject Terms:
ELECTRON SCATTERING GEOMAGNETISM LINES OF FORCE MAGNETIC FIELDS
Language Note: English
Notes:
Journal of Propulsion and Power (ISSN 0748-4658), vol. 6, Sept.-Oct. 1990, p. 559-566.

TITLE: ***Ion drag on a highly negatively biased solar array***

Document ID: **19910028818** A (91A13441) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hastings, Daniel E. Cho, Mengu (MIT)
Journal Title: Space Power - Resources, Manufacturing and Development **Volume**: 9 **Issue**: 2-3,
Published: Jan 01, 1990
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 13
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: SOLAR PHYSICS
Abstract:
Highly biased solar arrays are found to have a number of significant interactions with the space environment. The negatively biased parts of the array undergo enhanced ion drag and also suffer from destructive arcing. The enhanced drag suffered by highly biased solar arrays is studied with the PIC code. A new model of the drag is developed and the results are compared to recent experimental work. The drag calculations contain the effect of having the conductor surrounded by dielectrics as well as the charging of the dielectric by electrons.
Major Subject Terms:
AEROSPACE ENVIRONMENTS BIAS DRAG ION IRRADIATION SOLAR ARRAYS SPACECRAFT CHARGING
Minor Subject Terms:
EARTH ORBITS SPACE PLASMAS TECHNOLOGICAL FORECASTING
Language Note: English
Notes:
Space Power - Resources, Manufacturing and Development (ISSN 0883-6272), vol. 9, no. 2-3, 1990, p. 99-111.

TITLE: ***Threshold voltage for arcing on negatively biased solar arrays***

Document ID: **19910029623** A (91A14246) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Hastings, Daniel E. (Physical Sciences, Inc.) Weyl, Guy (Physical Sciences, Inc.) Kaufman, Donald (Physical Sciences, Inc.)

Journal Title: Journal of Spacecraft and Rockets **Volume**: 27 **Page**: 539-544
Published: Oct 01, 1990
Corporate Source:

Physical Sciences, Inc. (Andover, MA, United States)

Pages: 6
Contract Number: NAS3-25402
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

The arcing that has been found to occur when negatively biased high-voltage solar arrays in LEO lie at a critical voltage with respect to the plasma environment is presently proposed to be due to a breakdown of gas emitted under electron bombardment from the solar cells' cover-glass. The elements of the model for this phenomenon include an electron current flow from the interconnect to a neighboring cover-glass, which desorbs neutral molecules under the electron bombardment. The neutral molecules form a gas over the interconnect, and this gas breaks down when the voltage over the interconnect is sufficiently high. Specific scaling predictions are made on the basis of the geometric structure and gas in question.

Major Subject Terms:

EARTH ORBITAL ENVIRONMENTS ELECTRIC ARCS SOLAR ARRAYS

Minor Subject Terms:

DYNAMIC MODELS ELECTRIC CURRENT ELECTRON BOMBARDMENT HIGH VOLTAGES

Language Note: English
Notes:

Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Sept.-Oct. 1990, p. 539-544.

TITLE: ***Where do negatively biased solar arrays arc?***

Document ID: **19910029626** A (91A14249) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Thiemann, H. (Physikalisch-Technische Studien GmbH) Schunk, R. W. (Utah State University) Bogus-K. (ESTEC)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 27 **Page**: 563-565
Published: Oct 01, 1990
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 3
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Experimental results are presented from solar array-LEO plasma interaction ground tests for the case of negatively biased solar array modules, with a view to the relationship between the degree of degradation of a sample and a given voltage regime. The novel failure mode studied in this negative voltage range occurs at solar cell edges, rather than at the interconnectors, as in other experiments. The arc discharges between solar cell edge regions and Kapton foil begin at voltages of -200 V; arc discharges occur only once at a given location.
Major Subject Terms:
EARTH IONOSPHERE ELECTRIC ARCS SOLAR ARRAYS SPACE PLASMAS
Minor Subject Terms:
EARTH ORBITAL ENVIRONMENTS PLASMA PHYSICS
Language Note: English
Notes:
Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 27, Sept.-Oct. 1990, p. 563-565.

TITLE: ***Particle flows to shape and voltage surface discontinuities in the electron sheath surrounding a high voltage solar array in LEO***

Document ID: **19910034757** A (91A19380) **File Series**: Open Literature
Report Number: AIAA PAPER 91-0603
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Metz, Roger N. (Colby College)
Published: Jan 01, 1991
Corporate Source:
Colby Coll. (Waterville, ME, United States)
Pages: 9
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
This paper discusses the numerical modeling of electron flows from the sheath surrounding high positively biased objects in LEO (Low Earth Orbit) to regions of voltage or shape discontinuity on the biased surfaces. The sheath equations are derived from the Two-fluid, Warm Plasma Model. An equipotential corner and a plane containing strips of alternating voltage bias are treated in two dimensions. A self-consistent field solution of the sheath equations is outlined and is pursued through one cycle. The electron density field is determined by numerical solution of Poisson's equation for the electrostatic potential in the sheath using the NASCAP-LEO relation between electrostatic potential and charge density. Electron flows are calculated numerically from the electron continuity equation. Magnetic field effects are not treated.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS SOLAR ARRAYS SPACECRAFT CHARGING TWO FLUID MODELS
Minor Subject Terms:
BIAS ELECTRON DENSITY PROFILES LOW EARTH ORBITS POISSON EQUATION SELF CONSISTENT FIELDS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 9 p.

TITLE: ***Dielectric charging processes and arcing rates of high voltage solar array***

Document ID: **19910034758** A (91A19381) **File Series**: Open Literature
Report Number: AIAA PAPER 91-0605
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Cho, Mengu Hastings, Daniel E. (MIT)
Published: Jan 01, 1991
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 11
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
When high voltage solar arrays are used in the LEO environment, serious interactions are known to occur between the solar cell material and the surrounding plasmas. Arcing is known to be the most severe interaction. The charging process of the dielectric coverglass by charged particles is studied numerically. If there is a field emission site with a high electric field enhancement factor beta on the interconnector, charging process due to enhanced field electron emission can be initiated and leads to the Townsend breakdown in the neutral gas desorbed from the coverglass. Based on this arcing onset model, the arcing rate is calculated taking the reciprocal of the charging time and the threshold voltage is found to be a few hundred volts negative independent of the ambient ion density.
Major Subject Terms:
ARC DISCHARGES EARTH ORBITAL ENVIRONMENTS ELECTRIC CHARGE HIGH VOLTAGES SOLAR ARRAYS SPACE PLASMAS
Minor Subject Terms:
CHARGED PARTICLES SOLAR CELLS TECHNOLOGICAL FORECASTING
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991. 11 p.

TITLE: ***Environmental interactions on Space Station***

Document ID: **19910045091** A (91A29714) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Garrett, Henry B. (Jet Propulsion Lab., California Inst. of Tech.) Gabriel, Stephen B. (Jet Propulsion Lab., California Inst. of Tech.) Murphy, Gerald B. (JPL)
Published: Jan 01, 1990
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 17
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
This paper describes the key environment/system interactions associated with the Space Station and its companion polar platform and defines the range of test environments that will need to be simulated. These environments include the neutral atmosphere, the ionospheric plasma, natural and man-made particulates, the ambient magnetic field, the South Atlantic Anomaly, and the ram/wake environment. The system/environment interactions include glow, oxygen erosion, drag, radiation effects, induced electric fields, high-voltage solar-array effects, and EMC/EMI associated with plasma/neutral gas operations. The Space Station and its associated systems pose unique demands on the ability to simulate these effects; synergistic effects require multiple environments to be simulated simultaneously, and the long life requirements require proper scaling of the exposure time. The analysis of specific effects and the calibration or improvement of ground test techniques will likely require in situ evaluation. Qualification and acceptance testing, because of cost and the impractically of extensive on-orbit analysis/modification, will likely remain ground test objectives except in very rare cases.
Major Subject Terms:
ELECTROMAGNETIC INTERFERENCE SPACE STATION POLAR PLATFORMS SPACECRAFT CHARGING SPACECRAFT ENVIRONMENTS
Minor Subject Terms:
EXTRAVEHICULAR ACTIVITY MAGNETIC EFFECTS RADIATION EFFECTS SPACE DEBRIS
Language Note: English
Notes:
IN: Aerospace Testing Seminar, 12th, Manhattan Beach, CA, Mar. 13-15, 1990, Proceedings (A91-29689 11-38). Mount Prospect, IL, Institute of Environmental Sciences, 1990, p. 163-179.
Aerospace Testing Seminar Manhattan Beach, CA Mar. 13-15, 1990

TITLE: ***Interaction of HV-biased current collectors with their LEO space environment***

Document ID: **19910053402** A (91A38025) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Raitt, W. J. (Utah State University)
Published: Jan 01, 1990
Corporate Source:
Utah State Univ. (Logan, UT, United States)
Pages: 6
Contract Number: DNA001-87-C-0015
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The interaction of spaceborne power systems is considered from the point of view of leakage current flow to the ionospheric plasma and enhanced leakage due to modification of the plasma environment caused by the power system. Following a brief survey of the LEO (low-earth-orbit) environment and the physical processes occurring in the interaction, some relevant experimental results from several sounding rocket flights are presented. Data from NASA experiments where particle beam emission both charges the platform and modifies the plasma environment are given. In addition, other data from a SDIO/DNA program are used to illustrate the effects of differently biased structures at electrical potentials up to 45 kV. In general, the results show that in the ambient LEO environment the interaction at potentials in the tens of kilovolts range is quite benign for the geometry used; however, if that environment is perturbed by the emission of gas from onboard systems, then much higher currents can flow to an exposed power system.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS PLASMA INTERACTIONS ROCKET SOUNDING SPACECRAFT CHARGING SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
COMPUTERIZED SIMULATION DEFENSE PROGRAM ENVIRONMENT EFFECTS LOW EARTH ORBITS SPACE PLATFORMS
Language Note: English
Notes:
IN: IECEC-90; Proceedings of the 25th Intersociety Energy Conversion Engineering Conference, Reno, NV, Aug. 12-17, 1990. Vol. 2 (A91-37926 15-20). New York, American Institute of Chemical Engineers, 1990, p. 7-12.
Intersociety Energy Conversion Engineering Conference Reno, NV Aug. 12-17, 1990

TITLE: ***Current collection and current closure in the Tethered Satellite System***

Document ID: **19910058913** A (91A43536) **File Series**: Open Literature
Report Number: AIAA PAPER 91-1476
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Drobot, Adam (Science Applications International Corp.) Satyanarayana, P. (Science Applications International Corp.) Chang, Chia-Lie (Science Applications International Corp.) Tsang, Kang (Science Applications International Corp.) Papadopoulos, Dennis (Science Applications International Corp.)

Published: Jun 01, 1991
Corporate Source:

Science Applications International Corp. (McLean, VA, United States)

Pages: 6
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:

Current collection and closure-path modeling are examined analytically with respect to the Tethered Satellite System (TSS). A particle-in cell code is compared with a one-dimensional unmagnetized fluid code to model the behavior of a positively charged satellite in the ionosphere. The morphology of the sheath and the sheath-region processes are thus examined, and the influence of ions leaving the sheath region is found to cause the attraction of an electron current that is 40 times greater than the steady state value. The enhancement is transient and enhances the acceleration of the electrons in the sheath. A set of modified MHD equations, including those for ion inertia, quasineutrality, and electron drift, is employed to model TSS current closure. Whistler modes are found to exist and can be excited as the TSS passes through the ionosphere. Important conclusions include a significant fluctuation level in the steady state sheath, an ion void which affects the electron population, and some long-lived electrons trapped in the settled sheath with respect to two directions.

Major Subject Terms:

ELECTRIC CURRENT SAFETY FACTORS SPACECRAFT CHARGING TETHERED SATELLITES

Minor Subject Terms:

FIELD ALIGNED CURRENTS MAGNETOHYDRODYNAMIC FLOW MAGNETOHYDRODYNAMICS PLASMA SHEATHS TETHERLINES

Language Note: English
Notes:

AIAA, Fluid Dynamics, Plasma Dynamics and Lasers Conference, 22nd, Honolulu, HI, June 24-26, 1991. 6 p. NASA-supported research.

TITLE: ***Analysis of ion densities in the vicinity of space vehicles - Ion-neutral chemical kinetics***

Document ID: **19910062745** A (91A47368) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Dressler, Rainer A. Gardner, James A. Cooke, David L. Murad, Edmond (USAF, Phillips Laboratory, Hanscom AFB)
Journal Title: Journal of Geophysical Research **Volume**: 96 **Page**: 13
Published: Aug 01, 1991
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 12
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
Recent laboratory studies of ion-molecule reactions relevant to the analysis of ion densities in the vicinity of space vehicles in low-earth orbit are discussed. The studies include new cross section measurements of the important O(+) + H2O charge transfer collisions and the H3O(+)-producing charge-transfer reaction rate is found to be less collision-energy dependent than previously assumed, whereas the H3O(+)-producing reaction rate is highest at thermal energies and decreases rapidly with increasing collision energy. Implications of the results on previous interpretations and recent space observations are discussed.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS IONIC REACTIONS NEUTRAL PARTICLES REACTION KINETICS SPACE PLASMAS SPACECRAFT CHARGING
Minor Subject Terms:
CHARGE TRANSFER IONIZATION CROSS SECTIONS LOW EARTH ORBITS
Language Note: English
Notes:
Journal of Geophysical Research (ISSN 0148-0227), vol. 96, Aug. 1, 1991, p. 13,795-13,806.
95-13,806

TITLE: ***Data analysis and interpretation related to space system/environment interactions at LEO altitude***

Document ID: **19920004968** N (92N14186) **File Series**: NASA Technical Reports
Report Number: NASA-CR-189524 NAS 1.26:189524
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Raitt, W. John (Utah State Univ.) Schunk, Robert W. (Utah State Univ.)
Published: Dec 01, 1991
Corporate Source:
Utah State Univ. (Logan, UT, United States)
Pages: 46
Contract Number: None
NASA Subject Category: MATERIALS PROCESSING
Abstract:
Several studies made on the interaction of active systems with the LEO space environment experienced from orbital or suborbital platforms are covered. The issue of high voltage space interaction is covered by theoretical modeling studies of the interaction of charged solar cell arrays with the ionospheric plasma. The theoretical studies were complemented by experimental measurements made in a vacuum chamber. The other active system studied was the emission of effluent from a space platform. In one study the emission of plasma into the LEO environment was studied by using initially a 2-D model, and then extending this model to 3-D to correctly take account of plasma motion parallel to the geomagnetic field. The other effluent studies related to the releases of neutral gas from an orbiting platform. One model which was extended and used determined the density, velocity, and energy of both an effluent gas and the ambient upper atmospheric gases over a large volume around the platform. This model was adapted to study both ambient and contaminant distributions around smaller objects in the orbital frame of reference with scale sizes of 1 m. The other effluent studies related to the interaction of the released neutral gas with the ambient ionospheric plasma. An electrostatic model was used to help understand anomalously high plasma densities measured at times in the vicinity of the space shuttle orbiter.
Major Subject Terms:
ATMOSPHERIC COMPOSITION EARTH ORBITAL ENVIRONMENTS EFFLUENTS HIGH VOLTAGES MAGNETIC FIELDS MATHEMATICAL MODELS NEUTRAL GASES SOLAR CELLS SPACE PLASMAS
Minor Subject Terms:
CONTAMINANTS ELECTROSTATICS GEOMAGNETISM PARTICLE MOTION PLASMA DENSITY PLASMAS (PHYSICS) SPACE PLATFORMS SPACE SHUTTLE ORBITERS THREE DIMENSIONAL MODELS VACUUM CHAMBERS
Language Note: English

TITLE: ***NASCAP/LEO simulations of Shuttle Orbiter charging during the SAMPIE experiment***

Document ID: **19920013118** N (92N22361) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:
Chock, Ricaurte (NASA Lewis Research Center)
Journal Title: NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 **Page**: p 655-661
Published: Feb 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 7
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The electrostatic charging of the Space Shuttle Orbiter during the operation of the Solar Array Module Plasma Interaction Experiment (SAMPIE) was modeled using the NASA Charging Analyzer Program/ low Earth orbit (NASCAP/LEO) computer code. The SAMPIE experiment consists of an array of various solar cells representing the present technologies. The objectives of the experiment are to investigate the arcing and current collection characteristics of these cells when biased to high potentials in a LEO plasma. NASCAP/LEO is a 3-D code designed to simulate the electrostatic charging of a spacecraft exposed to a plasma at LEO or ground test conditions. At its most extreme configuration, with the largest array segment of the SAMPIE experiment biased + 600 V with respect to the orbiter and facing the ram direction, the computer simulations predict that the orbiter's potential will be approximately -20 V with respect to the plasma.
Major Subject Terms:
COMPUTERIZED SIMULATION ELECTROSTATIC CHARGE PLASMA INTERACTION EXPERIMENT SOLAR ARRAYS SOLAR CELLS SPACE PLASMAS SPACE SHUTTLE ORBITERS SPACECRAFT CHARGING
Minor Subject Terms:
APPLICATIONS PROGRAMS (COMPUTERS) BIAS GROUND TESTS LOW EARTH ORBITS MATHEMATICAL MODELS
Language Note: English
Notes:
In NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 p 655-661 (SEE N92-22324 13-59)

TITLE: ***PASP Plus: An experiment to measure space-environment effects on photovoltaic power subsystems***

Document ID: **19920013119** N (92N22362) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:
Guidice, Donald A. (Phillips Lab.)
Journal Title: NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 **Page**: p 662-668
Published: Feb 01, 1992
Corporate Source:
Phillips Lab. (Hanscom AFB, MA, United States)
Pages: 7
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The Photovoltaic Array Space Power Plus Diagnostic experiment (PASP Plus) was accepted as part of the APEX Mission payload aboard a Pegastar satellite to be orbited by a Pegasus launch vehicle in late 1992. The mission's elliptical orbit will allow us to investigate both space plasma and space radiation effects. PASP Plus will have eleven types of solar arrays and a full complement of environmental and interactions diagnostic sensors. Measurements of space-plasma interactions on the various solar arrays will be made at large negative voltages (to investigate arcing parameters) and at large positive voltages (to investigate leakage currents) by biasing the arrays to various levels up to -500 and +500 volts. The long-term deterioration in solar array performance caused by exposure to space radiation will also be investigated; radiation dosage will be measured by an electron/proton dosimeter included in the environmental sensor complement. Experimental results from PASP Plus will help establish cause-and-effect relationships and lead to improved design guidelines and test standards for new-technology solar arrays.
Major Subject Terms:
PHOTOVOLTAIC CELLS PLASMA DIAGNOSTICS PLASMA INTERACTIONS PLASMA RADIATION SOLAR ARRAYS SPACE PLASMAS SPACECRAFT POWER SUPPLIES SPHINX
Minor Subject Terms:
DOSIMETERS ELECTRIC POTENTIAL ELLIPTICAL ORBITS EXTRATERRESTRIAL RADIATION LAUNCH VEHICLES LEAKAGE RADIATION DOSAGE RADIATION EFFECTS RADIATION HAZARDS
Language Note: English
Notes:
In NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 p 662-668 (SEE N92-22324 13-59)

TITLE: ***Spacecraft-plasma interaction codes: NASCAP/GEO, NASCAP/LEO, POLAR, DynaPAC, and EPSAT***

Document ID: **19920013121** N (92N22364) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:
Mandell, M. J. (Maxwell Labs., Inc., La Jolla) Jongeward, G. A. (Maxwell Labs., Inc., La Jolla) Cooke, D. L. (Phillips Lab.)
Journal Title: NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 **Page**: p 672-679
Published: Feb 01, 1992
Corporate Source:
Systems Science and Software (La Jolla, CA, United States)
Pages: 8
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Development of a computer code to simulate interactions between the surfaces of a geometrically complex spacecraft and the space plasma environment involves: (1) defining the relevant physical phenomena and formulating them in appropriate levels of approximation; (2) defining a representation for the 3-D space external to the spacecraft and a means for defining the spacecraft surface geometry and embedding it in the surrounding space; (3) packaging the code so that it is easy and practical to use, interpret, and present the results; and (4) validating the code by continual comparison with theoretical models, ground test data, and spaceflight experiments. The physical content, geometrical capabilities, and application of five S-CUBED developed spacecraft plasma interaction codes are discussed. The NASA Charging Analyzer Program/geosynchronous earth orbit (NASCAP/GEO) is used to illustrate the role of electrostatic barrier formation in daylight spacecraft charging. NASCAP/low Earth orbit (LEO) applications to the CHARGE-2 and Space Power Experiment Aboard Rockets (SPEAR)-1 rocket payloads are shown. DynaPAC application to the SPEAR-2 rocket payloads is described. Environment Power System Analysis Tool (EPSAT) is illustrated by application to Tethered Satellite System 1 (TSS-1), SPEAR-3, and Sundance. A detailed description and application of the Potentials of Large Objects in the Auroral Region (POLAR) Code are presented.
Major Subject Terms:
COMPUTER PROGRAMS COMPUTERIZED SIMULATION ELECTROSTATICS PLASMA INTERACTIONS SPACE PLASMAS SPACEBORNE EXPERIMENTS SPACECRAFT CHARGING
Minor Subject Terms:
AURORAL ZONES GROUND TESTS LOW EARTH ORBITS MATHEMATICAL MODELS
Language Note: English
Notes:
In NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 p 672-679 (SEE N92-22324 13-59)

TITLE: ***Ion collection from a plasma by a pinhole***

Document ID: **19920013125** N (92N22368) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:
Snyder, David B. (NASA Lewis Research Center) Herr, Joel L. (Sverdrup Technology, Inc., Cleveland)
Journal Title: NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 **Page**: p 694-702
Published: Feb 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 9
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
Ion focusing by a biased pinhole is studied numerically. Laplace's equation is solved in 3-D for cylindrical symmetry on a constant grid to determine the potential field produced by a biased pinhole in a dielectric material. Focusing factors are studied for ions of uniform incident velocity with a 3-D Maxwellian distribution superimposed. Ion currents to the pinhole are found by particle tracking. The focusing factor of positive ions as a function of initial velocity, temperature, injection radius, and hole size is reported. For a typical Space Station Freedom environment (oxygen ions having a 4.5 eV ram energy, 0.1 eV temperature, and a -140 V biased pinhole), a focusing factor of 13.35 is found for a 1.5 mm radius pinhole.
Major Subject Terms:
DIELECTRICS ION CURRENTS MATHEMATICAL MODELS OXYGEN IONS PARTICLE TRACKS PINHOLES POTENTIAL FIELDS SPACE PLASMAS SPACE STATION FREEDOM SPACECRAFT STRUCTURES
Minor Subject Terms:
BIAS CYLINDRICAL BODIES LAPLACE EQUATION MAXWELL-BOLTZMANN DENSITY FUNCTION OXIDE FILMS POSITIVE IONS SPUTTERING SYMMETRY VELOCITY DISTRIBUTION
Language Note: English
Notes:
In NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 p 694-702 (SEE N92-22324 13-59)

TITLE: ***Current flow in a plasma caused by dielectric breakdown***

Document ID: **19920013130** N (92N22373) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:
Vaughn, J. A. (NASA Marshall Space Flight Center) Carruth, M. R., Jr. (NASA Marshall Space Flight Center) Gray, P. A. (Sverdrup Technology, Inc., Huntsville)
Journal Title: NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 **Page**: p 724-731
Published: Feb 01, 1992
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 8
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
Spacecraft with a thin dielectric coating on the outer surface of the structure which are biased (-200 V) negative relative to the atmospheric plasma are susceptible to dielectric breakdown. This paper will present experimental tests designed to measure the electron current flow from the structure through the plasma during the arc. The current path was examined in three parts: the electrons supplied through the structure and the arc to the outer structure, the expansion of the arc into the ambient plasma, and the return current through the ambient plasma. The measured electron current either flowing from the plasma or supplied to the plasma by the arc in each case was compared to the random thermal electron current which could be collected. The results of the tests show a spacecraft is capable of supporting arcs with peak currents greater than thermal electron currents, and these currents will be dependent upon the amount of stored charge in the structure (i.e., the structure's surface area and dielectric thickness). Also, the results of these tests show that it is possible for structures with a self capacitance of 10 microFarads to see peak currents of 90 A and structures with 1000 microFarads (i.e., capacitance of one Space Station Freedom module) to produce peak currents of 1000 A.
Major Subject Terms:
BREAKDOWN CAPACITANCE DIELECTRICS PLASMA CURRENTS PLASMAS (PHYSICS) SPACE PLASMAS
Minor Subject Terms:
BIAS ELECTRIC FIELDS ELECTRON ENERGY SPACE STATION FREEDOM
Language Note: English
Notes:
In NASA. Johnson Space Center, 5th Annual Workshop on Space Operations Applications and Research (SOAR 1991), Volume 2 p 724-731 (SEE N92-22324 13-59)

TITLE: ***Long Duration Exposure Facility (LDEF) preliminary findings: LEO space effects on the space plasma-voltage drainage experiment***

Document ID: **19920015571** N (92N24814) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A06
Authors:
Blakkolb, Brian K. (TRW Space and Defense Sector) Yaung, James Y. (TRW Space and Defense Sector) Henderson, Kelly A. (TRW Space and Defense Sector) Taylor, William W. (TRW Space and Defense Sector) Ryan, Lorraine E. (TRW Space and Defense Sector)
Journal Title: NASA. Langley Research Center, LDEF: 69 Months in Space. First Post-Retrieval Symposium, Part 2 **Page**: p 737-752
Published: Jan 01, 1992
Corporate Source:
TRW Space and Defense Sector (Redondo Beach, CA, United States)
Pages: 16
Contract Number: None
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:
The Space Plasma-High Voltage Drainage Experiment (SP-HVDE) provided a unique opportunity to study long term space environmental effects on materials because it was comprised of two identical experimental trays; one tray located on the ram facing side (D-10), and the other on the wake facing side (B-4) of the LDEF. This configuration allows for the comparison of identical materials exposed to two distinctly different environments. The purpose of this work is to document an assessment of the effects of five and three quarters years of low Earth orbital space exposure on materials comprising the SP-HVDE (experiment no. A0054). The findings of the materials investigation reported focus on atomic oxygen effects, micrometeor and debris impact site documentation, thermal property measurements, and environmentally induced contamination.
Major Subject Terms:
DRAINAGE HIGH VOLTAGES LONG DURATION EXPOSURE FACILITY OXYGEN ATOMS RADIATION EFFECTS SPACE DEBRIS SPACE PLASMAS
Minor Subject Terms:
AEROSPACE ENVIRONMENTS CONTAMINATION ENVIRONMENT EFFECTS HYPERVELOCITY IMPACT MICROMETEOROIDS SPACEBORNE EXPERIMENTS TEMPERATURE EFFECTS
Language Note: English
Notes:
In NASA. Langley Research Center, LDEF: 69 Months in Space. First Post-Retrieval Symposium, Part 2 p 737-752 (SEE N92-24806 15-99)

TITLE: ***Solar Array Module Plasma Interaction Experiment (SAMPIE): Technical requirements document***

Document ID: **19920019440** N (92N28683) **File Series**: NASA Technical Reports
Report Number: NASA-TM-105660 E-7033 NAS 1.15:105660
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:

Hillard, G. Barry (Sverdrup Technology, Inc., Brook Park) Ferguson, Dale C. (NASA Lewis Research Center)

Published: May 01, 1992
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 25
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:

The Solar Array Module Plasma Interactions Experiment (SAMPIE) is a NASA shuttle space flight experiment scheduled for launch in early 1994. The SAMPIE experiment will investigate plasma interactions of high voltage space power systems in low earth orbit. Solar cell modules, representing several technologies, will be biased to high voltages to characterize both arcing and plasma current collection. Other solar modules, specially modified in accordance with current theories of arcing and breakdown, will demonstrate the possibility of arc suppression. Finally, several test modules will be included to study the basic nature of these interactions. The science and technology goals for the project are defined in the Technical Requirements Document (TRD) which is presented here.

Major Subject Terms:

HIGH VOLTAGES PLASMA CURRENTS PLASMA INTERACTION EXPERIMENT PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS SPACEBORNE EXPERIMENTS SPACECRAFT POWER SUPPLIES

Minor Subject Terms:

BIAS EARTH ORBITS LAUNCHING LOW EARTH ORBITS MODULES

Language Note: English

TITLE: ***Dielectric charging processes and arcing rates of high voltage solar arrays***

Document ID: **19920037764** A (92A20388) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Cho, Mengu Hastings, Daniel E. (MIT)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 28 **Page**: 698-706
Published: Dec 01, 1991
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 9
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
No Abstract Available
Major Subject Terms:
ARC DISCHARGES EARTH ORBITAL ENVIRONMENTS ELECTRIC CHARGE SOLAR ARRAYS SPACE PLASMAS
Minor Subject Terms:
CHARGED PARTICLES HIGH VOLTAGES SOLAR CELLS TECHNOLOGICAL FORECASTING
Language Note: English
Notes:
(AIAA, Aerospace Sciences Meeting, 29th, Reno, NV, Jan. 7-10, 1991, AIAA Paper 91-0605) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 28, Nov.-Dec. 1991, p. 698-706. Previously cited in issue 06, p. 821, Accession no. A91-19381.
Previously cited in issue 06, p. 821, Accession no. A91-19381

TITLE: ***Predicted potentials and currents for TSS-1***

Document ID: **19920044357** A (92A26981) **File Series**: Open Literature
Report Number: AIAA PAPER 92-0574
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Davis, V. A. Katz, I. Luu, T. T. (Maxwell Laboratories, Inc.) Oberhardt, M. R. (USAF, Phillips Laboratory, Hanscom AFB)
Published: Jan 01, 1992
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 8
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The distribution of voltages is calculated as predicted for the elements of the Tethered Satellite System 1 (TSS-1) and the tether currents for the range of predicted conditions. Orbiter-ion collection is calculated with the 3D NASCAP/LEO code with attention given to orientation, potential, and plasma conditions. The resulting data is integrated into the EPSAT mission-analysis code to determine the results in terms of spacecraft-environment interactions. The subsatellite surface and the orbiter are shown to support potentials of more than 2 kV and about 1 kV under conditions of low ionospheric plasma density. During periods of the maximum ambient density the expected currents can reach 250 mA, and a range of 10-100 kiloohm is given for the orbiter ion-collecting sheath impedance. It is concluded that the sheath ionization can potentially damage the subsatellite equipment.
Major Subject Terms:
ELECTRIC POTENTIAL ION CURRENTS SPACECRAFT CHARGING TETHERED SATELLITES WAVE-PARTICLE INTERACTIONS
Minor Subject Terms:
CURRENT DISTRIBUTION IONIZATION SPACE PLASMAS SPACE SHUTTLE PAYLOADS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Research supported by USAF.

TITLE: ***The arcing rate for a High Voltage Solar Array - Theory, experiment and predictions***

Document ID: **19920044359** A (92A26983) **File Series**: Open Literature
Report Number: AIAA PAPER 92-0576
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hastings, Daniel E. (NASA Lewis Research Center) Cho, Mengu (MIT) Kuninaka, Hitoshi (Institute of Space and Astronautical Science)
Published: Jan 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 28
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
All solar arrays have biased surfaces which can be exposed to the space environment. It has been observed that when the array bias is less than a few hundred volts negative then the exposed conductive surfaces may undergo arcing in the space plasma. A theory for arcing is developed on these high voltage solar arrays which ascribes the arcing to electric field runaway at the interface of the plasma, conductor and solar cell dielectric. Experiments were conducted in the laboratory for the High Voltage Solar Array (HVSA) experiment which will fly on the Japanese Space Flyer Unit (SFU) in 1994. The theory was compared in detail to the experiment and shown to give a reasonable explanation for the data. The combined theory and ground experiments were then used to develop predictions for the SFU flight.
Major Subject Terms:
ELECTRIC ARCS HIGH VOLTAGES SOLAR ARRAYS SPACE PLASMAS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
SPACECRAFT CHARGING THERMAL EXPANSION
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 28 p. Research supported by NASA, NSF, USAF, et al.

TITLE: ***Arcing of negatively biased solar cells in low earth orbit***

Document ID: **19920044361** A (92A26985) **File Series**: Open Literature
Report Number: AIAA PAPER 92-0578
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Upschulte, B. L. (NASA Lewis Research Center)   Weyl, G. M. (NASA Lewis Research Center)
Marinelli, W. J. (Physical Sciences, Inc.)   Aifer, E. (Boston University)   Hastings, D. (MIT)
Published: Jan 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 8
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
A set of experiments is described in which the arcing of negatively biased solar cells is examined and characterized in terms of the primary factors that cause such behavior. The experiments are conducted in an ultrahigh vacuum chamber, and an image-intensified CCD camera is employed to monitor UV emission from arc events at the interfacial edge between the cover slip and the solar cell. A bead of encapsulant along the interfacial edge is noted which can be removed to reduce arc frequency, and water contamination is found to further enhance arcing. Frequency of arcing is found to vary indirectly with temperature and directly with exposure to H2O, but no other significant correlations are noted. The sensitivity to H2O vapor is eliminated by simply removing the adhesive/encapsulant, and the corresponding arc-rate performance is low.
Major Subject Terms:
BIAS   EARTH ORBITAL ENVIRONMENTS   LOW EARTH ORBITS   SOLAR CELLS   SPACE PLASMAS   WATER VAPOR
Minor Subject Terms:
CHARGE COUPLED DEVICES   HIGH VOLTAGES   ULTRAHIGH VACUUM   ULTRAVIOLET RADIATION
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p. Research supported by NASA.

TITLE: ***Analytical and computer modeling of spacecraft potentials***

Document ID: **19920044515** A (92A27139) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Mandell, Myron J. (Maxwell Laboratories, Inc.)
Published: Jan 01, 1992
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 18
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The present effort to model spacecraft electrical potentials proceeds by characterizing the electrical currents and electrostatic interactions between idealized surfaces and the plasma encountered by spacecraft in LEO, giving attention to the relative importance of various terms for a thin, hot plasma, as represented by a magnetic substorm, vs a dense cold plasma, as represented by the LEO environment. Phenomena associated with real spacecraft, which complicate surface-potential calculations, are noted. Calculations are presented for illustrative cases of various physical conditions and electrical and geometrical configurations.
Major Subject Terms:
COMPUTERIZED SIMULATION ELECTRIC POTENTIAL PLASMA CURRENTS SPACECRAFT CHARGING
Minor Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRON SCATTERING ELECTROSTATICS MAGNETIC STORMS
Language Note: English
Notes:
IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings (A92-27130 10-18). Toulouse, France, Cepadues-Editions, 1992, p. 243-260.
International Course on Space Technology Toulouse Nov. 26-30, 1990

TITLE: ***Environmental interactions of solar generators in low earth orbit***

Document ID: **19920044519** A (92A27143) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Bogus, K. (ESTEC), Thiemann, H. (Thiemann & Noack)
Published: Jan 01, 1992
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 19
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The state of the art in solar array interactions with the environment in LEO is reviewed. Emphasis is given to the design, development, and testing of arrays with regard to their interaction with plasma, micrometeorites, high-energy charged particles, and electrostatic charging. The effect of atomic oxygen, UV radiation, and solar thermal cycles, and solar eclipses on the survivability of solar generators in LEO are also considered.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS LOW EARTH ORBITS SOLAR ARRAYS SOLAR GENERATORS SPACECRAFT CHARGING
Minor Subject Terms:
MICROMETEOROIDS SPACE PLASMAS SPACECRAFT CONTAMINATION SPACECRAFT POWER SUPPLIES
Language Note: English
Notes:
IN: Space environment: Prevention of risks related to spacecraft charging; International Course on Space Technology, Toulouse, France, Nov. 26-30, 1990, Proceedings (A92-27130 10-18). Toulouse, France, Cepadues-Editions, 1992, p. 367-385.
International Course on Space Technology Toulouse Nov. 26-30, 1990

TITLE: ***Electrical breakdown of Space Station Freedom surfaces***

Document ID: **19920046969** A (92A29593) **File Series**: Open Literature
Report Number: AIAA PAPER 92-0820
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Carruth, M. R., Jr. (NASA Marshall Space Flight Center) Vaughn, J. A. (NASA Marshall Space Flight Center) Bechtel, R. T. (NASA Marshall Space Flight Center) Gray, P. A. (Sverdrup Technology, Inc.)

Published: Jan 01, 1992
Corporate Source:

NASA Marshall Space Flight Center (Huntsville, AL, United States)

Pages: 8
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

Space Station Freedom (SSF) will be the largest and highest power spacecraft that the U.S. has put into orbit. The solar array will generate 160 volts nominal when in sunlight, and the present baseline design is for the negative end of the solar array to be tied to SSF structure. Due to the balance of leakage currents through the plasma, the structure will be driven approximately 140 volts negative of the ambient conductive ionospheric plasma. Surface materials such as anodized aluminum will have this voltage drop across a thin dielectric which may not have sufficient dielectric strength to prevent dielectric breakdown. This can lead to arcing on the exterior surfaces of Space Station.

Major Subject Terms:

ELECTRICAL FAULTS SOLAR ARRAYS SPACE STATION FREEDOM SPACE STATION STRUCTURES SPACECRAFT CHARGING

Minor Subject Terms:

IONOSPHERIC CONDUCTIVITY PLASMA POTENTIALS SUNLIGHT THERMODYNAMIC PROPERTIES

Language Note: English
Notes:

AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 8 p.

TITLE: ***Extrapolation of electrical breakdown currents from the laboratory to Space Station***

Document ID: **19920046970** A (92A29594) **File Series**: Open Literature
Report Number: AIAA PAPER 92-0822
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Vaughn, Jason A. (NASA Marshall Space Flight Center) Carruth, Melvin R., Jr. (NASA Marshall Space Flight Center) Katz, Ira (NASA Marshall Space Flight Center) Mandell, Myron J. (NASA Marshall Space Flight Center) Jongeward, Gary A. (Maxwell Laboratories, Inc.)

Published: Jan 01, 1992
Corporate Source:

NASA Marshall Space Flight Center (Huntsville, AL, United States)

Pages: 9
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:

Recent experiments conducted in a plasma chamber at NASA/MSFC on anodized aluminum coatings representative of Space Station Freedom design show that if the aluminum used as a thermal control coating is biased more than 80 V negative with respect to the plasma, the anodization will experience dielectric breakdown. As the thin anodization layer creates a capacitive charge buildup, large currents are observed during the arc. How plasma generation at the arc site can support large currents and discharge the surface charge layer is investigated. The importance for Space Station Freedom is that currents similar to those observed in the laboratory can be observed on orbit.

Major Subject Terms:

ELECTRICAL FAULTS EXTRAPOLATION SPACE PLASMAS SPACE STATION FREEDOM SPACECRAFT CHARGING SPACECRAFT CONTAMINATION

Minor Subject Terms:

ANODIZING EARTH ORBITAL ENVIRONMENTS ELECTRIC POTENTIAL GROUND TESTS SOLAR ARRAYS TEMPERATURE GRADIENTS THERMAL CONTROL COATINGS

Language Note: English
Notes:

AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 9 p.

TITLE: ***The possibility of critical velocity ionization near the Space Station - Simulation results***

Document ID: **19920046989** A (92A29613) **File Series**: Open Literature
Report Number: AIAA PAPER 92-0847
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Biasca, Rodger J. Hastings, Daniel E. (MIT) Cooke, David L. (USAF, Phillips Laboratory, Hanscom AFB)
Published: Jan 01, 1992
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 7
Contract Number: F19628-90-K-0021
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
This paper investigates the possibility of the 'critical velocity ionization' of the effluents of thruster firings or other neutral gas releases from an orbiting vehicle. One-dimensional particle-in-cell simulations are used to derive reaction rates for the anomalous ionization process. These reaction rates are then used to suggest the magnitude of possible plasma density increases near the vehicle. If critical velocity ionization should occur, the results show that order of magnitude increases in the plasma density are possible.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS EXHAUST GASES GAS IONIZATION MAGNETOPLASMADYNAMICS SPACE STATION PROPULSION
Minor Subject Terms:
EFFLUENTS ION PRODUCTION RATES NEUTRAL GASES PARTICLE IN CELL TECHNIQUE PLASMA DENSITY REACTION KINETICS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992. 7 p.

TITLE: ***Plasma effects on the passive external thermal control coating of Space Station Freedom***

Document ID: **19920056115** A (92A38739) **File Series**: Open Literature
Report Number: AIAA PAPER 92-1685
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Carruth, Ralph, Jr. (NASA Marshall Space Flight Center) Vaughn, Jason A. (NASA Marshall Space Flight Center) Holt, James M. (NASA Marshall Space Flight Center) Werp, Richard (NASA Marshall Space Flight Center) Sudduth, Richard D. (Boeing Defense and Space Group)
Published: Mar 01, 1992
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 21
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The current baseline chromic acid anodized thermal control coating on 6061-T6 aluminum meteoroid debris (M/D) shields for SSF has been evaluated. The degradation of the solar absorptance, alpha, and the thermal emittance, epsilon, of chromic acid anodized aluminum due to dielectric breakdown in plasma was measured to predict the on-orbit lifetime of the SSF M/D shields. The lifetime of the thermal control coating was based on the surface temperatures achieved with degradation of the thermal control properties, alpha and epsilon. The temperatures of each M/D shield from first element launch (FEL) through FEL+15 years were analyzed. It is shown that the baseline thermal control coating cannot withstand the -140 V potential between the conductive structure of the SSF and the current plasma environment.
Major Subject Terms:
METEOROID PROTECTION PLASMA INTERACTIONS SPACE STATION FREEDOM SPACECRAFT CHARGING SPACECRAFT SHIELDING THERMAL CONTROL COATINGS
Minor Subject Terms:
ANODIZING CHROMIC ACID DIELECTRICS ELECTRIC ARCS SPACE DEBRIS
Language Note: English
Notes:
AIAA, Space Programs and Technologies Conference, Huntsville, AL, Mar. 24-27, 1992. 21 p.

TITLE: ***Arcing of negatively biased solar cells in a plasma environment. I - Experimental observations***

Document ID: **19920064376** A (92A47000) **File Series**: Open Literature
Report Number: AIAA PAPER 92-2990
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Upschulte, B. L. (NASA Lewis Research Center) Marinelli, W. J. (NASA Lewis Research Center) Weyl, G. (NASA Lewis Research Center) Carleton, K. L. (Physical Sciences, Inc.) Aifer, E. (Boston University)

Published: Jul 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 16
Contract Number: NAS3-25797
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

A variety of experiments have been performed which identify key factors contributing to the arcing of negatively biased high voltage solar cells operating in a low earth orbit plasma environment. These efforts have led to a reduction of greater than a factor of 100 in the arc frequency of a single cells following proper remeditation procedures. Experiments naturally led to and focused on the adhesive/encapsulating that is used to bond the protective cover slip to the solar cell. An image-intensified CCD camera system recorded UV emission from arc events which occurred exclusively along the interfacial edge between the cover slip and the solar cell. Microscopic inspection of this interfacial region showed a bead of encapsulant along this entire edge. Elimination of this encapsulant bead reduced the arc frequency by two orders of magnitude.

Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRIC ARCS PLASMA-ELECTROMAGNETIC INTERACTION SOLAR CELLS SPACE PLASMAS SPACECRAFT PROPULSION
Minor Subject Terms:
LOW EARTH ORBITS SATELLITE SOLAR ENERGY CONVERSION SOLAR ARRAYS ULTRAVIOLET EMISSION
Language Note: English
Notes:
AIAA, Plasmadynamics and Lasers Conference, 23rd, Nashville, TN, July 6-8, 1992. 16 p.

TITLE: ***Recent experimental measurements of space platform charging at LEO altitudes***

Document ID: **19920065310** A (92A47934) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Raitt, W. J. (Utah State University) Myers, N. B. (USAF, Rome Air Development Center) Thompson, D. C. (Utah State University) Banks, P. M. (Michigan, University) Gilchrist, B. E. (NASA Goddard Space Flight Center) Neubert, T. (NASA Goddard Space Flight Center) Williamson, P. R. (Stanford University) Sasaki, S. (Institute of Space and Astronautical Science)
Journal Title: Advances in Space Research **Volume**: 12 **Issue**: 12, D
Published: Dec 01, 1992
Corporate Source:
NASA Goddard Space Flight Center (Greenbelt, MD, United States)
NASA (Washington, DC, United States)
Pages: 4
Contract Number: DNA001-87-C-0015
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The paper discusses some of the results of vehicle electrical potential from recent sounding rocket experiments involving charging of a space platform by both electron beam emission and by the application of differential bias between elements of the platform. Conclusions are presented that are applicable to the experimental parameters of the CHARGE-2 and SPEAR-1 payloads. The currents collected by HV biased collectors in the sphere show strong magnetic limiting and are close to the values predicted by Parker and Murphy (1967). No volume breakdown was observed above 100 km altitude by exposing voltages up to 45 kV to the ionosphere in the SPEAR-1 payload. The release of gas at flow rates typical of ACS systems can provide sufficient plasma to electronically neutralize space platforms biased at either positive or negative potentials.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRON BEAMS ROCKET SOUNDING SPACE PLATFORMS VOLT-AMPERE CHARACTERISTICS
Minor Subject Terms:
ELECTRIC POTENTIAL PLASMA WAVES SPACE CHARGE
Language Note: English
Notes:
(Active experiments in space; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission D /Meeting D3/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-47926 20-46) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 12, Dec. 1992, p. 49-52.

TITLE: ***Field formation around negatively biased solar arrays in the LEO-plasma***

Document ID: **19920065323** A (92A47947) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Thiemann, H. (Thiemann and Noack) Schunk, R. W. (Utah State University)
Journal Title: Advances in Space Research **Volume**: 12 **Issue**: 12, D
Published: Dec 01, 1992
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 4
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The electric field formation around negatively biased solar cells and the influence of impacting energized plasma ions are investigated. The calculations are based on a particle-in-cell model. Snapshots of the equipotential lines at the end of the simulations are shown. Very efficient shielding of the interconnector was observed in all cases. Impacting ions first contribute to a reduction of the negative polarization charges. With the emission of electrons, this discharging is enhanced by the remaining positive surface charges. With more intense electron emission, the associated higher positive surface charges still accelerate the discharging process. The quantitative results for the electric fields near the array surface are illustrated.
Major Subject Terms:
COMPUTERIZED SIMULATION EARTH ORBITAL ENVIRONMENTS PARTICLE IN CELL TECHNIQUE SOLAR ARRAYS SOLAR CELLS
Minor Subject Terms:
ARC DISCHARGES DIELECTRIC PROPERTIES THERMAL PLASMAS
Language Note: English
Notes:
(Active experiments in space; Proceedings of the Topical Meeting of the Interdisciplinary Scientific Commission D /Meeting D3/ of the COSPAR 28th Plenary Meeting, The Hague, Netherlands, June 25-July 6, 1990. A92-47926 20-46) Advances in Space Research (ISSN 0273-1177), vol. 12, no. 12, Dec. 1992, p. 143-146.

TITLE: ***Assessment of environmental effects on Space Station Freedom Electrical Power System***

Document ID: **19920067957** A (92A50581) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Lu, Cheng-Yi (Rockwell International Corp.) Nahra, Henry K. (NASA Lewis Research Center)
Published: Jan 01, 1991
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Analyses of EPS (electrical power system) interactions with the LEO (low earth orbit) environment are described. The results of these analyses will support EPS design so as to be compatible with the natural and induced environments and to meet power, lifetime, and performance requirements. The environmental impacts to the Space Station Freedom EPS include aerodynamic drag, atomic oxygen erosion, ultraviolet degradation, VXB effect, ionizing radiation dose and single event effects, electromagnetic interference, electrostatic discharge, plasma interactions (ion sputtering, arcing, and leakage current), meteoroid and orbital debris threats, thermal cycling effects, induced current and voltage potential differences in the SSF due to induced electric field, and contamination degradation.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS IMPACT DAMAGE PLASMA INTERACTIONS RADIATION DAMAGE SPACE STATION FREEDOM SPACE STATION POWER SUPPLIES SPACECRAFT CONTAMINATION
Minor Subject Terms:
EARTH IONOSPHERE ENVIRONMENTAL TESTS IONIZING RADIATION LOW EARTH ORBITS SOLAR ARRAYS SPACE PLASMAS SYSTEMS ENGINEERING
Language Note: English
Notes:
IN: IECEC '91; Proceedings of the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, Aug. 4-9, 1991. Vol. 1 (A92-50526 21-20). La Grange Park, IL, American Nuclear Society, 1991, p. 374-379.
IECEC '91: Intersociety Energy Conversion Engineering Conference Boston, MA Aug. 4-9, 1991

TITLE: ***PASP, a high voltage array/plasma interaction experiment***

Document ID: **19920067958** A (92A50582) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Burger, Dale R. (JPL)
Published: Jan 01, 1991
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 5
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The author discusses the photovoltaic array space power (PASP) experiment, which is designed to obtain data on the interaction between high-voltage photovoltaic arrays and the polar, low-earth plasma environment. Up to six small test arrays (three each of planar and concentrator designs) can be voltage biased over a range of 500 V. During the bias voltage sequence, the array current leakage is measured and array arc events are monitored. If any arcing occurs the arc characteristics will be measured by a transient pulse monitor. An emitter is included to allow voltage bias to be applied to a plasma-charged or uncharged spacecraft. Similarly, the frames of the concentrator arrays can be left floating or can be tied to the negative array terminal. An environmental data scan is made before each bias voltage sequence. This scan collects information on the plasma, array-current-versus-voltage curves, and neutral particle partial pressure. The requirement for high voltages created problems which were met by circuit isolation and logical fault protection.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS HIGH VOLTAGES PHOTOVOLTAIC CONVERSION PLASMA INTERACTIONS SOLAR ARRAYS SPACEBORNE EXPERIMENTS
Minor Subject Terms:
DATA ACQUISITION ELECTRIC ARCS SPACE PLASMAS SPACECRAFT CHARGING
Language Note: English
Notes:
IN: IECEC '91; Proceedings of the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, Aug. 4-9, 1991. Vol. 1 (A92-50526 21-20). La Grange Park, IL, American Nuclear Society, 1991, p. 380-384. Research sponsored by USAF.
IECEC '91: Intersociety Energy Conversion Engineering Conference Boston, MA Aug. 4-9, 1991

TITLE: ***The Solar Array Module Plasma Interactions Experiment (SAMPIE) - A Shuttle-based plasma interactions experiment***

Document ID: **19920067959** A (92A50583) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Wald, Lawrence W. (NASA Lewis Research Center) Hillard, G. B. (NASA Lewis Research Center)
Published: Jan 01, 1991
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The Solar Array Module Plasma Interactions Experiment (SAMPIE), an approved Shuttle space flight experiment with a tentative launch date in July 1993, is intended to investigate plasma interactions of high-voltage space power systems. Solar cell modules, representing several technologies, will be biased to high voltages to characterize both arcing (negative potential) and current collection (positive potential). Other solar modules, specially modified in accordance with current theories of arcing and breakdown, will demonstrate the possibility of arc suppression. Finally, several additional test specimens will be included to study the basic nature of these interactions. The authors describe the rationale for the space flight experiment, the measurements to be made, the significance of the expected results, and the current design status of the flight hardware.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS PLASMA INTERACTIONS SOLAR ARRAYS SPACEBORNE EXPERIMENTS
Minor Subject Terms:
ELECTRIC ARCS HIGH VOLTAGES SOLAR CELLS SPACE SHUTTLE PAYLOADS
Language Note: English
Notes:
IN: IECEC '91; Proceedings of the 26th Intersociety Energy Conversion Engineering Conference, Boston, MA, Aug. 4-9, 1991. Vol. 1 (A92-50526 21-20). La Grange Park, IL, American Nuclear Society, 1991, p. 385-390.
IECEC '91: Intersociety Energy Conversion Engineering Conference Boston, MA Aug. 4-9, 1991

TITLE: ***An analytical and particle simulation study of localized semivacuum gas breakdown phenomena on high-voltage surfaces in low earth orbit***

Document ID: **19920068216** A (92A50840) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Cho, Mengu Hastings, Daniel E. (MIT)
Journal Title: Physics of Fluids B **Volume**: 4 **Issue**: 8, Au
Published: Aug 01, 1992
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 12
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: PLASMA PHYSICS
Abstract:
Gas breakdown phenomena occurring on a localized scale of less than 1 mm in a semivacuum environment p is less than 1 (torr) are studied analytically as well as numerically using a Monte Carlo-particle-in-cell (MC-PIC) code. The MC-PIC code is shown to reproduce real physical phenomena with quantitative accuracy. The breakdown of a gas in semivacuum conditions is attributed to field enhancement by positive ion space charges resulting in higher enhanced field electron emission from the cathode surface. The analytical expression for the breakdown condition is derived, and very good agreement with the numerical and experimental results is obtained.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRON EMISSION LOW EARTH ORBITS MONTE CARLO METHOD PARTICLE IN CELL TECHNIQUE SPACECRAFT POWER SUPPLIES TRANSMISSION LINES
Minor Subject Terms:
HIGH VOLTAGES PLASMA DENSITY SOLAR ARRAYS SOLAR ENERGY CONVERSION
Language Note: English
Notes:
Physics of Fluids B (ISSN 0899-8221), vol. 4, no. 8, Aug. 1992, p. 2614-2625.

TITLE: ***LEO spacecraft leakage current and discharging phenomena - TRW LDEF SP-HVDE (space plasma-high voltage drainage experiment)***

Document ID: **19920070591** A (92A53215) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Yaung, J. Y. (NASA Langley Research Center) Wong, W. C. (NASA Langley Research Center) Blakkolb, B. K. (NASA Langley Research Center) Ryan, L. E. (NASA Langley Research Center) Taylor, W. W. L. (TRW Space & Technology Group)
Published: Jan 01, 1991
Corporate Source:
NASA Langley Research Center (Hampton, VA, United States)
Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Two identical SP-HVDE trays were flown in the NASA 5.75-year LDEF (Long Duration Exposure Facility), one near the leading edge and the other near the trailing edge, in the LEO (low earth orbit) environment. Each experiment tray consisted of six assemblies with each made of Kapton dielectric samples of varying thicknesses (i.e., 2 mils, 3 mils, and 5 mils) biased under 300 V, 500 V, and 1000 V. The objectives have been successfully achieved by measuring the first post-flight long-term (i.e. roughly 8-month experiment) average leakage current through 95 percent measurable coulombmeters and surface materials.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRIC DISCHARGES LONG DURATION EXPOSURE FACILITY SPACEBORNE EXPERIMENTS
Minor Subject Terms:
EXTRATERRESTRIAL RADIATION FILM THICKNESS KAPTON (TRADEMARK) LOW EARTH ORBITS OXYGEN ATOMS SPACE PLASMAS VOLT-AMPERE CHARACTERISTICS
Language Note: English
Notes:
IN: IEEE Photovoltaic Specialists Conference, 22nd, Las Vegas, NV, Oct. 7-11, 1991, Conference Record. Vol. 2 (A92-53126 22-44). New York, Institute of Electrical and Electronics Engineers, Inc., 1991, p. 1566-1571. Research supported by NASA.
IEEE Photovoltaic Specialists Conference Las Vegas, NV Oct. 7-11, 1991

TITLE: ***Dielectric charging process in high voltage solar cell arcing***

Document ID: **19920071023** A (92A53647) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Cho, Mengu Hastings, Daniel E. (MIT) Kuninaka, Hitoshi (Institute of Space and Astronautical Science)

Published: Jan 01, 1990
Corporate Source:

(Corporate Source(s) Not Available)

Pages: 6
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

When high voltage solar arrays are used in the LEO environment, serious interactions are known to occur between the solar cell material and the surrounding plasma. Arcing is known to be the most severe interaction. The charging process of the dielectric coverglass by charged particles is studied numerically. Three possible charging mechanisms are considered: ion charging, ion-induced secondary electron (IISE) charging and enhanced field emission electron (EFEE) charging. The IISE charging can lead to a steady state unless the EFEE charging becomes significant. If there is a field emission site with a high electric field enhancement factor beta on the interconnector, then EFEE charging can be initiated. Once the EFEE charging is initiated, it leads to the Townsend breakdown in the neutral gas desorbed from the coverglass. For a given geometry, the threshold voltage is determined by the upper limit of the field enhancement factor and calculated to be 220 volt.

Major Subject Terms:

DIELECTRIC PROPERTIES EARTH ORBITAL ENVIRONMENTS ION CHARGE SOLAR CELLS SPACECRAFT POWER SUPPLIES

Minor Subject Terms:

ELECTRIC CHARGE ELECTRON EMISSION HIGH VOLTAGES ION CURRENTS

Language Note: English
Notes:

IN: International Symposium on Space Technology and Science, 17th, Tokyo, Japan, May 20-25, 1990, Proceedings. Vol. 2 (A92-53451 23-12). Tokyo, AGNE Publishing, Inc., 1990, p. 1421-1426.

International Symposium on Space Technology and Science Tokyo May 20-25, 1990

TITLE: ***Implications for the technology of high voltage solar arrays - The possibility of an arc resistant cell***

Document ID: **19920073254** A (92A55878) **File Series**: Open Literature
Report Number: IAF PAPER 92-0588
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hastings, Daniel E. Cho, Mengu Mong, Renee (MIT)
Published: Aug 01, 1992
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 12
Contract Number: AF-AFOSR-87-0340 NSF INT-88-15096
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
All solar arrays have biased surfaces which can be exposed to the space environment. It has been observed that when the array bias is less than a few hundred volts negative then the exposed conductive surfaces may undergo arcing in the space plasma. A theory for arcing has been developed on these high voltage solar arrays which ascribes the arcing to electric field runaway at the interface of the plasma, conductor and solar cell dielectric. The theory was compared in detail to the experimental data and shown to give a reasonable explanation for the data. The theory suggests that overhanging the coverglass over the triple junction will modify the field runaway. It is shown that there is a critical overhang beyond which field runaway is unlikely to occur in space and therefore arcing will be suppressed.
Major Subject Terms:
ELECTRIC ARCS HIGH VOLTAGES SOLAR ARRAYS SPACECRAFT CHARGING
Minor Subject Terms:
COVERINGS ELECTRIC FIELDS SOLAR ELECTRIC PROPULSION SPACE PLASMAS SPACE STATION FREEDOM SPACECRAFT POWER SUPPLIES
Language Note: English
Notes:
IAF, International Astronautical Congress, 43rd, Washington, Aug. 28-Sept. 5, 1992. 12 p.

TITLE: ***Acceptance testing of the prototype electrometer for the SAMPIE flight experiment***

Document ID: 19930001653 N (93N10841) **File Series**: NASA Technical Reports
Report Number: NASA-TM-105880 E-7343 NAS 1.15:105880
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Hillard, G. Barry (NASA Lewis Research Center)
Published: Sep 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 24
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The Solar Array Module **Plasma** Interaction Experiment (SAMPIE) has two key instruments at the heart of its data acquisition capability. One of these, the electrometer, is designed to measure both ion and electron **current** from most of the samples included in the experiment. The accuracy requirement, specified by the project's Principal Investigator, is for agreement within 10 percent with a calibrated laboratory instrument. **Plasma** chamber testing was performed to assess the capabilities of the prototype design. Agreement was determined to be within 2 percent for electron collection and within 3 percent for ion collection.
Major Subject Terms:
ELECTROMETERS PERFORMANCE TESTS **PLASMA** CURRENTS **PLASMA** INTERACTION EXPERIMENT SOLAR ARRAYS SPACEBORNE EXPERIMENTS
Minor Subject Terms:
ACCURACY CALIBRATING DATA ACQUISITION ELECTRON ENERGY ION CURRENTS PROTOTYPES SPACE PLASMAS
Language Note: English

TITLE: Environmental interactions and the SP-100 power system

Document ID: **19930009688** N (93N18877) **File Series**: NASA Technical Reports
Report Number: NASA-TM-105866 E-7328 NAS 1.15:105866
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01

Authors:
Ferguson, Dale C. (NASA Lewis Research Center)

Published: Jan 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 14
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER

Abstract:
Interactions of the SP-100 power system with its expected ambient environments are defined. SP-100 payloads will float 100 V negative of the low Earth orbit (LEO) plasma. Choice of proper geometries and materials will prevent arcing at conductor-insulator junctions in LEO. Care in selecting surface coatings will prevent dielectric breakdown. Sputtering is a concern for long-duration LEO missions. Atomic oxygen durability of SP-100 materials will be tested in ground and flight tests. Evaluation of SP-100 in lunar and planetary environments has begun. The report of a recent workshop on Chemical and Electrical Interactions on Mars identified many of the primary interactions.

Major Subject Terms:
PLANETARY ENVIRONMENTS PLASMA INTERACTIONS PLASMAS (PHYSICS) SPACE POWER REACTORS
Minor Subject Terms:
DURABILITY EARTH ORBITS FLIGHT TESTS GROUND TESTS LOW EARTH ORBITS LUNAR ENVIRONMENT OXYGEN ATOMS SPUTTERING
Language Note: English

TITLE: ***Ionospheric plasma flow about a system of electrically biased flat plates***

Document ID: **19930013942** N (93N23131) **File Series**: NASA Technical Reports
Report Number: NASA-CR-191119 E-7732 NAS 1.26:191119
Sales Agency & Price: CASI Hardcopy A05 CASI Microfiche A01
Authors:
Herr, Joel L. (Sverdrup Technology, Inc.)
Published: Apr 01, 1993
Corporate Source:
Sverdrup Technology, Inc. (Brook Park, OH, United States)
Pages: 95
Contract Number: NAS3-25266
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The steady state interaction of two electrically biased parallel plates immersed in a flowing plasma characteristic of low earth orbit is studied numerically. Fluid equations are developed to describe the motion of the cold positively charged plasma ions, and are solved using finite-differences in two dimensions on a Cartesian grid. The behavior of the plasma electrons is assumed to be described by the Maxwell-Boltzmann distribution. Results are compared to an analytical and a particle simulation technique for a simplified flow geometry consisting of a single semi-infinite negatively biased plate. Comparison of the extent of the electrical disturbance into the flowing plasma and the magnitude of the current collected by the plate is very good. The interaction of two equally biased parallel plates is studied as a function of applied potential. The separation distance at which the current collected by either plate decreases by five and twenty percent is determined as a function of applied potential. The percent decreases were based on a non-interacting case. The decrease in overall current is caused by a decrease in ionic density in the region between the plates. As the separation between the plates decreases, the plates collect the ions at a faster rate than they are supplied to the middle region by the oncoming plasma flow. The docking of spacecraft in orbit is simulated by moving two plates of unequal potential toward one another in a quasi-static manner. One plate is held at a large negative potential while the other floats electrically in the resulting potential field. It is found that the floating plate does not charge continuously negative as it approaches the other more negatively biased plate. Instead, it charges more and then less negative as ionic current decreases and then increases respectively upon approach. When the two plates come into contact, it is expected that the electrically floating plate will charge rapidly negative to a potential near that of the other plate.
Major Subject Terms:
MAGNETOHYDRODYNAMIC FLOW PARALLEL PLATES PLASMA INTERACTIONS POTENTIAL FIELDS SPACE ENVIRONMENT SIMULATION SPACECRAFT DOCKING
Minor Subject Terms:
BOLTZMANN DISTRIBUTION COLD PLASMAS FLOATING LOW EARTH ORBITS MAXWELL-BOLTZMANN DENSITY FUNCTION SPACECRAFT ORBITS
Language Note: English

TITLE: ***Plasma chamber testing of APSA coupons for the SAMPIE flight experiment***

Document ID: 19930014553 N (93N23742) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106084   E-7707   NAS 1.15:106084   AIAA PAPER 93-0568
Sales Agency & Price: CASI Hardcopy A02   CASI Microfiche A01
Authors:
Hillard, G. Barry (NASA Lewis Research Center)
Published: Jan 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 9
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Among the solar cell technologies to be tested in space as part of the Solar Array Module **Plasma** Interactions Experiment (SAMPIE) will be the Advanced Photovoltaic Solar Array (APSA). Several prototype twelve cell coupons were built for NASA using different blanket materials and mounting techniques. The first conforms to the baseline design for APSA which calls for the cells to be mounted on a carbon loaded Kapton blanket to control charging in GEO. When deployed, this design has a flexible blanket supported around the edges. A second coupon was built with the cells mounted on Kapton-H, which was in turn cemented to a solid aluminum substrate. A final coupon was identical to the latter but used germanium coated Kapton to control atomic oxygen attack in LEO. Ground testing of these coupons in a **plasma** chamber showed considerable differences in **plasma current** collection. The Kapton-H coupon demonstrated **current** collection consistent with exposed interconnects and some degree of cell snapover. The other two coupons experienced anomalously large collection currents. This behavior is believed to a consequence of enhanced **plasma** sheaths supported by the weakly conducting carbon and germanium used in these coupons. The results reported here are the first experimental evidence that the use of such materials can result in power losses to high voltage space power systems.
Major Subject Terms:
GROUND TESTS   KAPTON (TRADEMARK)   **PLASMA** CURRENTS   **PLASMA** INTERACTIONS   SOLAR ARRAYS   SOLAR CELLS   SPACE PLASMAS   SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
BLANKETS   HIGH VOLTAGES   OXYGEN ATOMS   **PLASMA** SHEATHS   SPACE SHUTTLE PAYLOADS   SPACEBORNE EXPERIMENTS   TEST CHAMBERS
Language Note: English
Notes:
Presented at the 31st Aerospace Sciences Meeting and Exhibit, Reno, NV, 11-14 Jan. 1993; sponsored by the AIAA
Aerospace Sciences Meeting and Exhibit Reno, NV 11-14 Jan. 1993

TITLE: ***Plasma sheath effects on ion collection by a pinhole***

Document ID: **19930015901** N (93N25090) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106098 E-7740 NAS 1.15:106098
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Herr, Joel L. (Sverdrup Technology, Inc.) Snyder, David B. (NASA Lewis Research Center)
Published: Apr 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 12
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
This work presents tables to assist in the evaluation of pinhole collection effects on spacecraft. These tables summarize results of a computer model which tracks particle trajectories through a simplified electric field in the plasma sheath. A technique is proposed to account for plasma sheath effects in the application of these results and scaling rules are proposed to apply the calculations to specific situations. This model is compared to ion current measurements obtained by another worker, and the agreement is very good.
Major Subject Terms:
COMPUTERIZED SIMULATION ION CURRENTS PARTICLE TRAJECTORIES PINHOLES PLASMA SHEATHS SPACECRAFT CHARGING
Minor Subject Terms:
ELECTRIC FIELDS LAPLACE EQUATION SPACE PLASMAS SPACECRAFT STRUCTURES SPUTTERING
Language Note: English
Notes:
Presented at the 31st AIAA Aerospace Sciences Meeting and Exhibit, Reno, NV, 11-14 Jan. 1993; sponsored by AIAA
AIAA Aerospace Sciences Meeting and Exhibit Reno, NV 11-14 Jan. 1993

TITLE: ***Plasma current collection of Z-93 thermal control paint as measured in the Lewis Research Center's plasma interaction facility***

Document ID: 19930017026 N (93N26215) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106132 E-7804 NAS 1.15:106132
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Hillard, G. Barry (NASA Lewis Research Center)
Published: Apr 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 14
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
A sample of Z-93 thermal control paint was exposed to a simulated space environment in a **plasma** chamber. The sample was biased through a series of voltages ranging from -100 volts to +300 volts and electron and ion currents were measured. Currents were found to be in the micro-ampere range indicating that the material remains a reasonably good insulator under **plasma** conditions. As a second step, the sample was left in the chamber for six days and retested. Collected currents were reduced by from two to five times from the previous values indicating a substantial loss of conductivity. As a final test, the sample was removed, exposed to room conditions for two days, and returned to the chamber. **Current** measurements showed that the sample had partially recovered the lost conductivity. In addition to presenting these results, this report documents all of the experimental data as well as the statistical analyses performed.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ENVIRONMENTAL TESTS PAINTS **PLASMA** CURRENTS **PLASMA** INTERACTIONS SPACE STATION FREEDOM SPACECRAFT CONSTRUCTION MATERIALS TEMPERATURE CONTROL
Minor Subject Terms:
ELECTRIC POTENTIAL INSULATORS ION CURRENTS STATISTICAL ANALYSIS TEST CHAMBERS
Language Note: English

TITLE: ***Space environmental interactions for the space exploration initiative***

Document ID: **19930017207** N (93N26396) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A02
Authors:

Ferguson, Dale C. (NASA Lewis Research Center)

Journal Title: Electrical and Chemical Interactions at Mars Workshop. Part 2: Appendix **Page**: p 69-85
Published: Jan 01, 1992
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 17
Contract Number: None
NASA Subject Category: LUNAR AND PLANETARY EXPLORATION
Abstract:

The topics are presented in viewgraph form and include the following: atomic oxygen attack; arcing and discharges; micrometeoroids and debris; state-of-the-art computer tools; current collection and snapover; effluents--neutral and ionized; and winds, dust, and contamination.

Major Subject Terms:

AEROSPACE ENVIRONMENTS COSMIC DUST ELECTRIC ARCS ELECTRIC DISCHARGES OXYGEN ATOMS SPACE DEBRIS SPACE EXPLORATION SPACECRAFT CHARGING SPACECRAFT CONTAMINATION

Minor Subject Terms:

EFFLUENTS MICROMETEOROIDS

Language Note: English
Notes:

In its Electrical and Chemical Interactions at Mars Workshop. Part 2: Appendix p 69-85 (SEE N93-26392 09-91)

TITLE: Enhanced *plasma current* collection from weakly conducting solar array blankets

Document ID: 19930017892 N (93N27081) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106168 E-7860 NAS 1.15:106168
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Hillard, G. Barry (NASA Lewis Research Center)
Published: May 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 23
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Abstract:
Among the solar cell technologies to be tested in space as part of the Solar Array Module **Plasma** Interactions Experiment (SAMPIE) will be the Advanced Photovoltaic Solar Array (APSA). Several prototype twelve cell coupons were built for NASA using different blanket materials and mounting techniques. The first conforms to the baseline design for APSA which calls for the cells to be mounted on a carbon loaded Kapton blanket to control charging in GEO. When deployed, this design has a flexible blanket supported around the edges. A second coupon was built with the cells mounted on Kapton-H, which was in turn cemented to a solid aluminum substrate. A final coupon was identical to the latter but used germanium coated Kapton to control atomic oxygen attack in LEO. Ground testing of these coupons in a **plasma** chamber showed considerable differences in **plasma current** collection. The Kapton-H coupon demonstrated **current** collection consistent with exposed interconnects and some degree of cell snapover. The other two coupons experienced anomalously large collection currents. This behavior is believed to be a consequence of enhanced **plasma** sheaths supported by the weakly conducting carbon and germanium used in these coupons. The results reported here are the first experimental evidence that the use of such materials can result in power losses to high voltage space power systems.

Major Subject Terms:
COATINGS KAPTON (TRADEMARK) **PLASMA** CURRENTS **PLASMA** SHEATHS SOLAR ARRAYS SOLAR CELLS SPACECRAFT CHARGING SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
ALUMINUM CEMENTATION GERMANIUM GROUND TESTS HIGH VOLTAGES OXYGEN ATOMS SPACE PLASMAS SUBSTRATES
Language Note: English

TITLE: ***Solar Array Module Plasma Interaction Experiment (SAMPIE)***

Document ID: **19930019527** N (93N28716) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A10
Authors:
Ferguson, Dale C. (NASA Lewis Research Center)
Journal Title: NASA, Washington, NASA(DOD Flight Experiments Technical Interchange Meeting Proceedings **Page**: 23 p
Published: Jan 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 23
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The objective of the Solar Array Module Plasma Interaction Experiment (SAMPIE) is to investigate, by means of a shuttle-based flight experiment and relevant ground-based testing, the arcing and current collection behavior of materials and geometries likely to be exposed to the LEO plasma on high-voltage space power systems, in order to minimize adverse environmental interactions. An overview of the SAMPIE program is presented in outline and graphical form.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS SOLAR ARRAYS SPACEBORNE EXPERIMENTS SPACECRAFT CHARGING SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
ELECTRIC ARCS HIGH VOLTAGES SPACE PLASMAS
Language Note: English
Notes:
In NASA, Washington, NASA/DOD Flight Experiments Technical Interchange Meeting Proceedings 23 p (SEE N93-28699 11-12)

TITLE: ***The Photovoltaic Array Space Power Plus diagnostics (PASP Plus) flight experiment***

Document ID: **19930019528** N (93N28717) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 • CASI Microfiche A10
Authors:

Piszczor, Michael F. (NASA Lewis Research Center) • Curtis, Henry B. (NASA Lewis Research Center) • Guidice, Donald A. (Phillips Lab.) • Severance, Paul S. (Phillips Lab.)

Journal Title: NASA, Washington, NASA(DOD Flight Experiments Technical Interchange Meeting Proceedings • **Page**: 34 p
Published: Jan 01, 1992
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 34
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:

An overview of the Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) flight experiment is presented in outline and graphic form. The goal of the experiment is to test a variety of photovoltaic cell and array technologies under various space environmental conditions. Experiment objectives, flight hardware, experiment control and diagnostic instrumentation, and illuminated thermal vacuum testing are addressed.

Major Subject Terms:

EARTH ORBITAL ENVIRONMENTS • PHOTOVOLTAIC CELLS • SOLAR ARRAYS • SOLAR CELLS • SPACEBORNE EXPERIMENTS • SPACECRAFT POWER SUPPLIES

Minor Subject Terms:

CONTROLLERS • MEASURING INSTRUMENTS • THERMAL VACUUM TESTS

Language Note: English
Notes:

In NASA, Washington, NASA/DOD Flight Experiments Technical Interchange Meeting Proceedings 34 p (SEE N93-28699 11-12)

TITLE: ***Arc mitigation on high voltage solar arrays***

Document ID: **19930039305** A (93A23302) **File Series**: Open Literature
Report Number: AIAA PAPER 93-0569
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Mong, Renee; Hastings, Daniel E. (MIT)
Published: Jan 01, 1993
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 15
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

In response to the increasing demand for higher power sources in space, solar arrays are being designed with high voltages to meet this need at low currents. Unfortunately, negatively biased high voltage solar cells have been observed to arc when exposed to the low earth orbit plasma environment. Cho and Hastings have developed analytic and numerical models of this arcing phenomenon which show excellent agreement with experimental data. This paper presents research in which these models are used to identify possible arcing mitigation strategies and to quantify their effectiveness. It was determined that the arcing rate can be decreased by (1) increasing the interconnector work function, (2) increasing the thickness of the coverglass and cover adhesive, (3) decreasing the secondary electron yield of the coverglass and adhesive, (4) decreasing the ratio of the coverglass/adhesive dielectric constants, and (5) overhanging the coverglass. Of these, methods (4) and (5) show the most promise in mitigating or even eliminating arcing.

Major Subject Terms:
ARC DISCHARGES; EARTH ORBITAL ENVIRONMENTS; SOLAR ARRAYS; SOLAR CELLS; SPACE PLASMAS
Minor Subject Terms:
HIGH VOLTAGES; LOW CURRENTS; LOW EARTH ORBITS; TECHNOLOGICAL FORECASTING; VOLT-AMPERE CHARACTERISTICS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993
AIAA, Aerospace Sciences Meeting and Exhibit Reno, NV Jan. 11-14, 1993

TITLE: ***Plasma sheath effects on ion collection by a pinhole***

Document ID: **19930040246** A (93A24243) **File Series**: Open Literature
Report Number: AIAA PAPER 93-0567
Sales Agency & Price: Issuing Activity
Authors:
Herr, Joel L. (Sverdrup Technology, Inc.) Snyder, David B. (NASA Lewis Research Center)
Published: Jan 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 11
Contract Number: NAS3-25266
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The data tabulations presented, which express the results of particle-track trajectories through a simplified plasma-sheath electric field, should prove useful in the assessment of spacecraft 'pinhole-collection' effects. Attention is given to a method accounting for plasma-sheath effects in the application of these results. In addition, scaling rules are given for the application of these calculations to specific cases. A comparison is made between the present model's results and those of recent ion current measurements. Good agreement is obtained.
Major Subject Terms:
COMPUTERIZED SIMULATION ION CURRENTS PARTICLE TRAJECTORIES PINHOLES PLASMA SHEATHS SPACECRAFT CHARGING
Minor Subject Terms:
LAPLACE EQUATION SPACE PLASMAS SPACECRAFT STRUCTURES
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993
AIAA, Aerospace Sciences Meeting and Exhibit Reno, NV Jan. 11-14, 1993

TITLE: ***Plasma chamber testing of APSA coupons for the SAMPIE flight experiment***

Document ID: 19930040247 A (93A24244) **File Series**: Open Literature
Report Number: AIAA PAPER 93-0568
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hillard, G. B. (NASA Lewis Research Center)
Published: Jan 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 8
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Different blanket materials and mounting techniques have been used to build 12 Advanced Photovoltaic Solar Array cell coupons for NASA's Solar Array Module **Plasma** Interactions Experiment. Ground testing of these coupons in a **plasma** chamber revealed significant differences among them in **plasma current** collection; while the Kapton-H coupon exhibited **current** collection consistent with the exposed interconnects, the other two coupon types tested experienced anomalously large collection currents. This may be due to enhanced **plasma** sheaths supported by the weakly conducting C and Ge employed in these coupons.
Major Subject Terms:
KAPTON (TRADEMARK)   OXYGEN ATOMS   **PLASMA** CURRENTS   **PLASMA** INTERACTIONS   SOLAR ARRAYS   TEST STANDS
Minor Subject Terms:
EARTH ORBITAL ENVIRONMENTS   GERMANIUM   PROTECTIVE COATINGS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993
AIAA, Aerospace Sciences Meeting and Exhibit Reno, NV Jan. 11-14, 1993

TITLE: ***Low earth orbit plasma effects on spacecraft***

Document ID: **19930040736** A (93A24733) **File Series**: Open Literature
Report Number: AIAA PAPER 93-0614
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Tribble, A. C. (Rockwell International Corp.)
Published: Jan 01, 1993
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 12
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Approximately one half of all new spacecraft are destined for the region between 100 and 1000 km termed LEO. A typical LEO spacecraft will utilize either battery power or low voltage solar arrays, (28 volts), for power generation and is designed for an operating life of at most a few years. As technology progresses the trend will be to design spacecraft with higher voltage electrical power systems and longer lifetimes. This paper first discusses the general characteristics of the LEO charging process in order to highlight the differences between the high current, low energy charging seen in LEO and the low current, high energy charging seen in geosynchronous orbits. This is followed by an examination of the various types of plasma interactions that a spacecraft in LEO may be subjected to with the objective being to identify how each of the various interactions is related to specific spacecraft design criteria.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS LOW EARTH ORBITS SPACE PLASMAS SPACECRAFT DESIGN
Minor Subject Terms:
CONTAMINANTS PLASMA DENSITY PLASMA INTERACTIONS SOLAR ARRAYS SPACECRAFT POWER SUPPLIES SYNCHRONOUS SATELLITES
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993
AIAA, Aerospace Sciences Meeting and Exhibit Reno, NV Jan. 11-14, 1993

TITLE: ***TSS-1 - Orbiter current and voltage experiments***

Document ID: **19930040801** A (93A24798) **File Series**: Open Literature
Report Number: AIAA PAPER 93-0702
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Thompson, D. C. (NASA Marshall Space Flight Center) Raitt, W. J. (Utah State Univ.) Bonifazi, C. (ASI) Williams, S. D. (NASA Marshall Space Flight Center) Aguero, V. M. (Stanford Univ.) Gilchrist, B. E. (NASA Marshall Space Flight Center) Banks, P. M. (Michigan Univ.)
Published: Jan 01, 1993
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 10
Contract Number: NAS8-39381 NAS8-36812
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Although the deployment distance of the TSS-1 tethered satellite was only about 1 percent of nominal, experiments to study the current collection and vehicle charging effects at low voltages were performed. We present measurements of Orbiter charging resulting from electron beam emission from the Orbiter, currents in the TSS system with and without electron beam emissions, and the effects of Orbiter thrusters on charging and currents. Generally, charging induced by beam emission was limited to a few volts, though during times with low ambient plasma density the Orbiter was charged up to 80 V. Thrusters are seen to enhance Orbiter charging during beam emission, and reduce ion current collection at other times.
Major Subject Terms:
ELECTRON BEAMS SPACE SHUTTLE ORBITERS SPACEBORNE EXPERIMENTS SPACECRAFT CHARGING TETHERED SATELLITES VOLT-AMPERE CHARACTERISTICS
Minor Subject Terms:
ELECTRIC CHARGE ELECTRIC CURRENT ELECTRIC POTENTIAL ELECTRICAL RESISTANCE INDUCTANCE SPACE SHUTTLE PAYLOADS
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993
AIAA, Aerospace Sciences Meeting and Exhibit Reno, NV Jan. 11-14, 1993

TITLE: ***Interactions between spacecraft and their environments***

Document ID: **19930040804** A (93A24801) **File Series**: Open Literature
Report Number: AIAA PAPER 93-0705
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Ferguson, Dale C. (NASA Lewis Research Center)
Published: Jan 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 11
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Interactions between spacecraft and their environments are discussed using the SSF and the SP-100 power system. It is recommended that discontinuous structure potentials of more than 100 V on a spacecraft must be connected with an insulating material of sufficient thickness to stand off the potential difference. Particular attention must be paid to conductors with a plasma arcing threshold higher than the conductor potential relative to the surrounding plasma. To avoid arcing, spacecraft surfaces should avoid exposed conductors, or at least exposed conductor-insulator junctions for LEO missions. To avoid differential charging, fully conductive surfaces should be used every where for GEO missions.
Major Subject Terms:
AEROSPACE ENVIRONMENTS CHEMICAL REACTIONS MICROMETEOROIDS PLASMA INTERACTIONS RADIATION EFFECTS SPACE DEBRIS SPACECRAFT CHARGING
Minor Subject Terms:
DIELECTRICS EARTH ORBITAL ENVIRONMENTS ELECTRICAL FAULTS LUNAR ENVIRONMENT OXYGEN ATOMS PLANETARY ENVIRONMENTS SPUTTERING
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993
AIAA, Aerospace Sciences Meeting and Exhibit Reno, NV Jan. 11-14, 1993

TITLE: ***Multibody-plasma interactions - Charging in the wake***

Document ID: **19930041543** A (93A25540) **File Series**: Open Literature
Report Number: AIAA PAPER 93-0564
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Wang, J. (Jet Propulsion Lab., California Inst. of Tech.) Leung, P. (Jet Propulsion Lab., California Inst. of Tech.) Murphy, G. (Jet Propulsion Lab., California Inst. of Tech.) Ruff, B. (JPL)
Published: Jan 01, 1993
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 9
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
Multibody-plasma interactions refers to two or more charged bodies simultaneously interacting with the surrounding plasma as well as each other. This paper concerns a basic type of such interactions in space: the charging of a free flyer in the wake of a large structure. The conditions for severe charging are discussed quantitatively. Computer particle simulations are carried out to obtain the charging potentials in the wake of both floating and biased plate. It is shown that a severe charging zone exists in the near wake of a floating plate within which a free flyer is charged to the KV range under the sun shadow/auroral electron condition. Whether the plate is biased or floating, a large potential difference always exists between the plate and a docking free flyer in the wake. The effects of wake charging on spacecraft docking operations are discussed.
Major Subject Terms:
EARTH IONOSPHERE PLASMA INTERACTIONS SPACECRAFT CHARGING
Minor Subject Terms:
CHARGED PARTICLES COMPUTERIZED SIMULATION FREE FLIGHT
Language Note: English
Notes:
AIAA, Aerospace Sciences Meeting and Exhibit, 31st, Reno, NV, Jan. 11-14, 1993
AIAA, Aerospace Sciences Meeting and Exhibit Reno, NV Jan. 11-14, 1993

TITLE: ***Computer particle simulation of high-voltage solar array arcing onset***

Document ID: **19930045160** A (93A29157) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Cho, Mengu Hastings, Daniel E. (MIT)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 30 **Issue**: 2 **Page**: p. 189-201.
Published: Apr 01, 1993
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 13
Contract Number: AF-AFOSR-87-0340
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The operation of a high-voltage solar array in low earth orbit may cause arcing on the negatively biased parts of a solar array. This sets a practical limit on the operational voltage of solar arrays. This paper is the extension of three earlier works regarding high-voltage solar array arcing. The onset of arcing is reproduced by self-consistent computer simulations to verify the arcing onset model developed in the earlier work. It is shown that neutral gas is desorbed from the dielectric surface forming a localized neutral cloud over the surface, and the arcing onset occurs as the gas breakdown at a parameter pd (pressure times distance) much smaller than the Paschen minimum. Analytical expressions for the prebreakdown electron currents and the neutral densities are also derived and used to obtain a parametric formula of the breakdown condition. Arcing rates are calculated including the breakdown condition of the desorbed neutral gas. The theory is compared to the Japanese Space Flyer Unit High-Voltage Solar Array ground experiment and shown to give a reasonable explanation for data relating the arcing rate to the solar array temperature.
Major Subject Terms:
COMPUTERIZED SIMULATION EARTH ORBITAL ENVIRONMENTS ELECTRIC ARCS SOLAR ARRAYS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
GROUND TESTS HIGH VOLTAGES JAPANESE SPACE PROGRAM JAPANESE SPACECRAFT LOW EARTH ORBITS SPACE CHARGE SPACE PLASMAS
Language Note: English
Notes:
Journal of Spacecraft and Rockets vol. 30, no. 2 p. 189-201. Mar.-Apr. 1993

TITLE: ***Arcing rates for High Voltage Solar Arrays - Theory, experiment, and predictions***

Document ID: **19930048570** A (93A32567) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hastings, Daniel E. (NASA Lewis Research Center) Cho, Mengu (MIT) Kuninaka, Hitoshi (Inst. of Space and Astronautical Science)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 29 **Issue**: 4 **Page**: p. 538-554.
Published: Aug 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 17
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
All solar arrays have biased surfaces that can be exposed to the space environment. It has been observed that when the array bias is less than a few hundred volts negative, then the exposed conductive surfaces may undergo arcing in the space plasma. A theory for arcing is developed on these high voltage solar arrays that ascribes the arcing to electric field runaway at the interface of the plasma, conductor, and solar cell dielectric. Experiments were conducted in the laboratory for the High Voltage Solar Array experiment that will fly on the Japanese Space Flyer Unit (SFU) in 1994. The theory was compared in detail with the experiment and shown to give a reasonable explanation for the data. The combined theory and ground experiments were then used to develop predictions for the SFU flight.
Major Subject Terms:
ELECTRIC ARCS PLASMA CLOUDS SOLAR ARRAYS SPACECRAFT PROPULSION
Minor Subject Terms:
HIGH VOLTAGES JAPANESE SPACECRAFT SPACE PLASMAS
Language Note: English
Notes:
Journal of Spacecraft and Rockets vol. 29, no. 4 p. 538-554. July-Aug. 1992
Research supported by NASA, NSF, USAF, and Japan Society for the Promotion of Science

---

TITLE: ***Arcing rate on solar array surface of solar power satellite, SPS2000***

Document ID: **19930054440** A (93A38437) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Cho, Mengu (Kobe Univ.)
Journal Title: Japan Society for Aeronautical and Space Sciences, Transactions **Volume**: 35 **Issue**: 110
Page: p. 221-236.
Published: Feb 01, 1993
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 16
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
Arcing rate on the solar array surface of solar power satellite, SPS2000, is calculated applying the arcing theory on high voltage solar arrays developed by Cho et al. assuming that arcs occur through holes on the insulator surface created by space debris impact. It is shown that the arcing rate strongly depends on the properties of enhanced field electron emission on the exposed conductor/semiconductor surface, which is the source of prebreakdown electron emission. The maximum number of arcs in the first day in the orbit is calculated to be 5600; most of the solar array modules on SPS2000 satellite may survive arcing.
Major Subject Terms:
ELECTRIC ARCS ELECTRICAL INSULATION IMPACT DAMAGE SOLAR ARRAYS SOLAR POWER SATELLITES
Minor Subject Terms:
DIELECTRICS ELECTRON EMISSION SILICON JUNCTIONS SOLAR CELLS
Language Note: English
Notes:
Japan Society for Aeronautical and Space Sciences, Transactions vol. 35, no. 110 p. 221-236. Feb. 1993

TITLE: ***Experimental studies on spacecraft arcing***

Document ID: **19930054984** A (93A38981) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:

Carruth, M. R., Jr. (NASA Marshall Space Flight Center) Vaughn, J. A. (NASA Marshall Space Flight Center) Bechtel, R. T. (NASA Marshall Space Flight Center) Gray, P. A. (Sverdrup Technologies, Inc.)

Journal Title: Journal of Spacecraft and Rockets **Volume**: 30 **Issue**: 3 **Page**: p. 323-327.
Published: Jun 01, 1993

Corporate Source:

NASA Marshall Space Flight Center (Huntsville, AL, United States)

Pages: 5
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:

No Abstract Available

Major Subject Terms:

ELECTRICAL FAULTS SOLAR ARRAYS SPACE STATION FREEDOM SPACE STATION STRUCTURES SPACECRAFT CHARGING

Minor Subject Terms:

IONOSPHERIC CONDUCTIVITY PLASMA POTENTIALS SUNLIGHT THERMODYNAMIC PROPERTIES

Language Note: English
Notes:

Journal of Spacecraft and Rockets vol. 30, no. 3 p. 323-327. May-June 1993

AIAA, Aerospace Sciences Meeting and Exhibit, 30th, Reno, NV, Jan. 6-9, 1992, AIAA Paper 92-0820. Previously cited in issue 11, p. 1740, Accession no. A92-29593

TITLE: ***Space Station Freedom structure floating potential and the probability of arcing***

Document ID: **19930055268** A (93A39265) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hastings, Daniel E. (NASA Lewis Research Center) Cho, Mengu (NASA Lewis Research Center) Wang, Jiong (MIT)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 29 **Issue**: 6 **Page**: p. 830-834.
Published: Dec 01, 1992
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 5
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The interaction between a space system and the space environment has been one of the driving questions for the design of spacecraft since the dawn of the space age. The Space Station Freedom will represent a significant increase in spacecraft size, power, and activity relative to spacecraft that are currently in orbit. The structure floating potential on Space Station Freedom is studied with simple analytical models of the current collection. The probability of arcing due to dielectric breakdown is assessed.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRIC ARCS LARGE SPACE STRUCTURES SPACE STATION FREEDOM SPACECRAFT DESIGN
Minor Subject Terms:
DIELECTRICS ELECTRIC POTENTIAL SOLAR ARRAYS SPACE PLASMAS
Language Note: English
Notes:
Journal of Spacecraft and Rockets vol. 29, no. 6 p. 830-834. Nov.-Dec. 1992

TITLE: ***Spacecraft charging - Progress in the study of dielectrics and plasmas***

Document ID: **19930055309** A (93A39306) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Robinson, P. A., Jr. (JPL),   Coakley, P. (Jaycor)
Journal Title: IEEE Transactions on Electrical Insulation **Volume**: 27 **Issue**: 5 **Page**: p. 944-960.
Published: Oct 01, 1992
Corporate Source:
Jet Propulsion Lab., California Inst. of Tech. (Pasadena, CA, United States)
Pages: 17
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The progress in spacecraft charging is reviewed with particular attention given to the interactions of plasma and penetrating radiation with dielectrics. Topics discussed include the charging environments, elementary charging theory, the anomalies attributed to charging or discharging phenomena, and spacecraft engineering.
Major Subject Terms:
DIELECTRICS   PLANETARY MAGNETOSPHERES   SPACE PLASMAS   SPACECRAFT CHARGING
Minor Subject Terms:
ELECTRIC DISCHARGES   ELECTRON ENERGY   ELECTRON PLASMA   ELECTROSTATICS
Language Note: English
Notes:
IEEE Transactions on Electrical Insulation vol. 27, no. 5 p. 944-960. Oct. 1992

TITLE: ***Solar array module plasma interactions experiment (SAMPIE) - Science and technology objectives***

Document ID: **19930062421** A (93A46418) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hillard, G. B. (NASA Lewis Research Center) Ferguson, Dale C. (NASA Lewis Research Center)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 30 **Issue**: 4 **Page**: p. 488-494.
Published: Aug 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 7
Contract Number: None
NASA Subject Category: SPACECRAFT PROPULSION AND POWER
Abstract:
The solar array module plasma interactions experiment (SAMPIE) is an approved NASA flight experiment manifested for Shuttle deployment in early 1994. The SAMPIE experiment is designed to investigate the interaction of high voltage space power systems with ionospheric plasma. To study the behavior of solar cells, a number of solar cell coupons (representing design technologies of current interest) will be biased to high voltages to measure both arcing and current collection. Various theories of arc suppression will be tested by including several specially modified cell coupons. Finally, SAMPIE will include experiments to study the basic nature of arcing and current collection. This paper describes the rationale for a space flight experiment, the measurements to be made, and the significance of the expected results. A future paper will present a detailed discussion of the engineering design.
Major Subject Terms:
PLASMA INTERACTIONS SOLAR ARRAYS SPACE SHUTTLE PAYLOADS SPACEBORNE EXPERIMENTS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
EARTH IONOSPHERE ELECTRIC ARCS ELECTROMAGNETIC INTERFERENCE SPACECRAFT CHARGING
Language Note: English
Notes:
Journal of Spacecraft and Rockets vol. 30, no. 4 p. 488-494. July-Aug. 1993

TITLE: ***Ionospheric plasma flow about a system of electrically biased flat plates***

Document ID: **19930062663** A (93A46660) **File Series**: Open Literature
Report Number: AIAA PAPER 93-3201
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Herr, J. L. (Sverdrup Technology, Inc.) Ibrahim, M. (Cleveland State Univ.)
Published: Jul 01, 1993
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 12
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
The steady state interaction of two electrically biased parallel plates immersed in a flowing plasma characteristic of low earth orbit is studied numerically. Fluid equations are developed to describe the motion of the cold positively charged plasma ions and are solved using finite differences in two dimensions on a Cartesian grid. The interaction of two equally biased parallel metallic plates is studied as a function of applied potential and plate length. The separation distance at which the current collected by the inner surface of either plate decreases by five and twenty percent as compared to a noninteracting case is determined as a function of applied potential. The decrease in overall current is caused by a decrease in ionic density in the region between the plates as the ions are collected by the plates at a faster rate than they are being supplied by the oncoming plasma flow. The docking of spacecraft in orbit is simulated by moving two metallic plates of unequal potential toward one another in a quasi-static manner. One plate is held at a large negative potential while the other floats electrically in the resulting potential field. It is found that the floating plate does not charge continuously negative as it approaches the other more negatively biased plate. Instead, it charges more and then less negative as ionic current decreases and then increases respectively upon approach.
Major Subject Terms:
ELECTRIC CURRENT FLAT PLATES IONOSPHERIC ION DENSITY MAGNETOHYDRODYNAMIC FLOW PLASMA DIAGNOSTICS RESPONSE BIAS
Minor Subject Terms:
EARTH ORBITAL ENVIRONMENTS LOW EARTH ORBITS MAXWELL-BOLTZMANN DENSITY FUNCTION METAL PLATES PARALLEL PLATES STEADY STATE
Language Note: English
Notes:
AIAA, Plasmadynamics and Lasers Conference, 24th, Orlando, FL, July 6-9, 1993
AIAA, Plasmadynamics and Lasers Conference Orlando, FL July 6-9, 1993

TITLE: ***Ion collection in a spacecraft wake - Laboratory simulations***

Document ID: **19930071567** A (93A55564) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Enloe, C. L. Cooke, D. L. (USAF, Phillips Lab.) Meassick, S. Chan, C. (Northeastern Univ.) Tautz, M. F. (Radex, Inc.)
Journal Title: Journal of Geophysical Research **Volume**: 98 **Issue**: A8 **Page**: p. 13,635-13,644.
Published: Aug 01, 1993
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 10
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
Data from a laboratory simulation of current collection by a highly biased body in a spacecraft wake are presented. Ion collection from the plasma stream is investigated for both axisymmetric and nonaxisymmetric geometries. Spatially resolved current collection data, obtained by using a segmented collector, are presented for the first time. A threshold potential for the onset of current collection exists; this threshold depends strongly on the geometry of the problem and is related directly to the details of the trajectories of the collected ions. Results from an approximate numerical model of the laboratory experiment as well as the predictions of a simplified analysis are given. The agreement of the numerical solution with the experimental data is good.
Major Subject Terms:
ION DENSITY (CONCENTRATION) SPACE PLASMAS SPACECRAFT CHARGING WAKES
Minor Subject Terms:
CHARGED PARTICLES COMPUTERIZED SIMULATION FLUX (RATE) MATHEMATICAL MODELS
Language Note: English
Notes:
Journal of Geophysical Research vol. 98, no. A8 p. 13,635-13,644. Aug. 1, 1993

TITLE: ***Electrodynamic aspects of the first tethered satellite mission***

Document ID: **19930071578** A (93A55575) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Dobrowolny, M. Melchioni, E. (CNR)
Journal Title: Journal of Geophysical Research **Volume**: 98 **Issue**: A8 **Page**: p. 13,761-13,778.
Published: Aug 01, 1993
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 18
Contract Number: None
NASA Subject Category: ASTRONAUTICS (GENERAL)
Abstract:

This paper aims at providing a thorough description of the basic electrodynamic aspects of a tethered satellite system (TSS) orbiting in the ionosphere. As will be seen, a wide variety of plasma physics phenomena are associated with the interaction of a conducting tether with the ionospheric plasma and, as a consequence, numerous basic science objectives can be addressed with a TSS system. Besides reviewing the various electrodynamic phenomena and our present knowledge on them, we provide also a description of the scientific payload and the nominal science objectives of the first tethered satellite project (TSS-1). A brief account, as well as a first evaluation, are also given of the mission itself, which was flown with the shuttle Atlantis launched on July 31, 1992.

Major Subject Terms:
EARTH IONOSPHERE ELECTRODYNAMICS PLASMA INTERACTIONS SPACE PLASMAS TETHERED SATELLITES
Minor Subject Terms:
ELECTRIC FIELDS MAGNETIC FLUX PAYLOADS SPACEBORNE EXPERIMENTS
Language Note: English
Notes:
Journal of Geophysical Research vol. 98, no. A8 p. 13,761-13,778. Aug. 1, 1993

TITLE: ***Experimental measurement of the plasma conductivity of Z93 and Z93P thermal control paint***

Document ID: 19940006301 N (94N10756) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106284 E-8022 NAS 1.15:106284
Sales Agency & Price: CASI Hardcopy A05 CASI Microfiche A01
Authors:
Hillard, G. Barry (NASA Lewis Research Center)
Published: Sep 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 77
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
Two samples each of Z93 and Z93P thermal control paint were exposed to a simulated space environment in a **plasma** chamber. The samples were biased through a series of voltages ranging from -200 volts to +300 volts and electron and ion currents measured. By comparing the currents to those of pure metal samples of the same size and shape, the conductivity of the samples was calculated. Measured conductivity was dependent on the bias potential in all cases. For Z93P, conductivity was approximately constant over much of the bias range and we find a value of 0.5 micro-mhos per square meter for both electron and ion **current**. For Z93, the dependence on bias was much more pronounced but conductivity can be said to be approximately one order of magnitude larger. In addition to presenting these results, this report documents all of the experimental data as well as the statistical analyses performed.
Major Subject Terms:
ELECTRICAL PROPERTIES PAINTS **PLASMA** CONDUCTIVITY SPACECRAFT CHARGING THERMAL CONTROL COATINGS
Minor Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRIC POTENTIAL ION CURRENTS STATISTICAL ANALYSIS ZINC OXIDES
Language Note: English

TITLE: TROPIX plasma interactions group report

Document ID: **19940017391** N (94N21864) **File Series**: NASA Technical Reports

Report Number: NASA-CR-191149 E-8169 NAS 1.26:191149

Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01

Authors:

Herr, Joel L. (Sverdrup Technology, Inc.) Chock, Ricaurte (NASA Lewis Research Center)

Published: Oct 01, 1993

Corporate Source:

Sverdrup Technology, Inc. (Brook Park, OH, United States)

Pages: 41

Contract Number: NAS3-25266

NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Abstract:

The purpose is to summarize the spacecraft charging analysis conducted by the plasma interactions group during the period from April 1993 to July 1993, on the proposed TROPIX spacecraft, and to make design recommendations which will limit the detrimental effects introduced by spacecraft charging. The recommendations were presented to the TROPIX study team at a Technical Review meeting held on 15 July 1993.

Major Subject Terms:

PLASMA INTERACTIONS SPACECRAFT CHARGING SPACECRAFT DESIGN

Minor Subject Terms:

EARTH ORBITAL ENVIRONMENTS GEOSYNCHRONOUS ORBITS RADIATION BELTS

Language Note: English

TITLE: ***The SAMPIE flight experimental final technical requirements document***

Document ID: **19940030223** N (94N34729) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106224 E-7942 NAS 1.15:106224
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Hillard, G. Barry (NASA Lewis Research Center) Ferguson, Dale C. (NASA Lewis Research Center)
Published: Jun 01, 1993
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 28
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The Solar Array Module Plasma Interactions Experiment (SAMPIE) is a shuttle based flight experiment scheduled for launch in early 1994. SAMPIE will investigate plasma interactions of high voltage space power systems in low earth orbit. Solar cell modules, representing several technologies, will be biased through a series of high voltages to characterize both arcing and plasma current collection. Other solar modules, specially modified in accordance with current theories of arcing and breakdown, will demonstrate the possibility of arc suppression. Finally, several test modules will be included to study the basic nature of these interactions. The science and technology goals for the project are defined in the Technical Requirements Document (TRD) which is presented here in its final form. The experiment is being developed at NASA LeRC in Cleveland, Ohio, and is sponsored by the NASA Office of Aeronautics and Space Technology (OAST).
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS PLASMA CURRENTS PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
AEROSPACE ENGINEERING BIAS EARTH ORBITS HIGH VOLTAGES LOW EARTH ORBITS RESEARCH AND DEVELOPMENT SPACECRAFT LAUNCHING
Language Note: English

TITLE: ***Electrical breakdown currents on large spacecraft in low Earth orbit***

Document ID: **19940036753** A (94A60202) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Vaughn, Jason A. (NASA Marshall Space Flight Center) Carruth, Melvin R. Katz, Ira Mandell, Myron J. Jongeward, Gary A.
Journal Title: Journal of Spacecraft and Rockets **Volume**: 31 **Issue**: 1 **Page**: p. 54-59
Published: Jan 01, 1994
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 6
Contract Number: None
NASA Subject Category: PHYSICS (GENERAL)
Abstract:
An experimental and theoretical investigation of an expanding plasma generated by an arc produced by biasing a conductor underneath a thin layer of anodized aluminum 160-V negative of a laboratory plasma that can produce large peak are currents by discharging large surface areas is presented. A simple theory shows that the time scales and observed current magnitudes are consistent with the expansion of a discharge-generated plasma. The implication for large spacecraft in low Earth orbit, such as Space Station Freedom (SSF) which can store large amounts of charge, is that arcs with the same amount of energy similar to those observed in the laboratory may occur.
Major Subject Terms:
EARTH ORBITS ELECTRICAL FAULTS LARGE SPACE STRUCTURES LOW EARTH ORBITS PLASMA DYNAMICS SPACE PLASMAS
Minor Subject Terms:
ALUMINUM ANODIZING CONDUCTORS GAS EXPANSION SPACE STATION FREEDOM SPACECRAFT ORBITS
Language Note: English
Notes:
Journal of Spacecraft and Rockets vol. 31, no. 1 p. 54-59 January-February 1994

TITLE: ***Operating in the space environment: A spacecraft charging study of the advanced x-ray astrophysics facility-spectroscopy spacecraft***

Document ID: **19950003365** N (95N71485) **File Series**: NASA Technical Reports
Report Number: NASA-TM-110645 NAS 1.15:110645
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A01
Authors:
Mccollum, Matthew B. (NASA Marshall Space Flight Center) Herr, Joel L. (Sverdrup Technology, Inc.) JAMES BONNIE F. (NASA Marshall Space Flight Center)
Published: Jan 01, 1993
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 4
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The effects attributed to spacecraft charging can be a serious engineering concern. Scientific instruments designed to measure properties of the natural space environment may have readings that are compromised due to the buildup of electric fields around the spacecraft. Charged surfaces may attract ionized contaminants, causing an increase in surface contamination. Arc-discharging is a rapid release of large amounts of charge. These discharges can cause physical surface damage and the discharge process can generate large structural currents which, when coupled into spacecraft electronics, can cause upsets and anomalies. Arc discharging is seen as the primary means by which spacecraft operations is disturbed by spacecraft charging. The effects of spacecraft charging bring about a need for space programs to adopt a plan to evaluate the impact of spacecraft charging related effects on spacecraft operations. This plan would be, in effect, a spacecraft charging protection plan. This protection plan involves defining the natural space plasma environment to which the spacecraft will be exposed, performing analyses to determine how interactions between the environment and spacecraft will affect the mission goals and objectives, and developing engineering design guidelines for the purpose of reducing or negating spacecraft charging related effects. This study presents the results of a spacecraft charging effects protection study conducted on the Advanced X-ray Astrophysics Facility-Spectroscopy (AXAF-S) spacecraft. Charging of the AXAF-S spacecraft due to auroral region environment is modeled using the POLAR (Potential Of Large spacecraft in Auroral Regions) computer code. Charging levels of exterior surfaces and the floating potential of the spacecraft relative to the ambient plasma are determined as a function of the spacecraft design, operational configuration, and orbital conditions. Areas where large surface voltage gradients exists on the AXAF-S spacecraft are identified as possible arc-discharge sites. Results of the charging analyses are the used to develop design recommendations that will limit the effects of spacecraft charging on the AXAF-S operation.
Major Subject Terms:
AEROSPACE ENVIRONMENTS ARC DISCHARGES AURORAL ZONES COMPUTERIZED SIMULATION SPACECRAFT CHARGING SPACECRAFT DESIGN X RAY ASTROPHYSICS FACILITY
Minor Subject Terms:
ELECTRIC FIELDS ELECTRIC POTENTIAL SPACE PLASMAS
Language Note: English

TITLE: ***Pre-flight POLAR code predictions for the CHAWS space flight experiment***

Document ID: **19950008185** N (95N14599) **File Series**: NASA Technical Reports
Report Number: AD-A280951 AD-E201983 PL-TR-94-2056 ERP-1147
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Cooke, David L. (Phillips Lab.) Talbot, John (Phillips Lab.) Shaw, Graeme (Phillips Lab.)
Published: Jan 31, 1994
Corporate Source:
Phillips Lab. (Hanscom AFB, MA, United States)
Pages: 18
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The POLAR code is a 3D plasma simulation which has been used to design and predict the behavior of the Charge Hazards and Wake Studies (CHAWS) space flight experiment. The most recent results from the POLAR code are presented here prior to the launch of the Space Shuttle Discovery. CHAWS will measure the current-voltage (IV) characteristics of a high voltage probe mounted on the wake side of the Wake Shield Facility (WSF) free flyer. POLAR results indicate that ion currents to the negatively biased probe will be near 'zero' only for potentials less than 30 to 300 V in magnitude. As the potential increases to the CHAWS limit of -5 kV, the ion current will quickly rise to levels comparable to that which the probe would collect if orbiting unshielded.
Major Subject Terms:
COMPUTER PROGRAMS COMPUTERIZED SIMULATION ION CURRENTS PLASMA SHEATHS SPACEBORNE EXPERIMENTS SPACECRAFT CHARGING VOLT-AMPERE CHARACTERISTICS
Minor Subject Terms:
EARTH ORBITS HIGH VOLTAGES POISSON EQUATION SPACE CHARGE SPACE SHUTTLES
Language Note: English

TITLE: ***Kapton pyrolysis, the space environment and wiring requirements***

Document ID: **19950009639** N (95N16054) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A02
Authors:
Ferguson, Dale C. (NASA Lewis Research Center)
Journal Title: First NASA Workshop on Wiring for Space Applications **Page**: p 125-131
Published: Sep 01, 1994
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 7
Contract Number: None
NASA Subject Category: ELECTRONICS AND ELECTRICAL ENGINEERING
Abstract:
New Low Earth Orbit (LEO) requirements of space environment wiring are compared with traditional requirements. The pyrolysis of Kapton is reviewed for the LeRc vacuum chamber and the 1989 SSF. SEEB modeling of Kapton pyrolysis is also presented.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS KAPTON (TRADEMARK) PYROLYSIS WIRING
Minor Subject Terms:
LOW EARTH ORBITS SPACE STATION FREEDOM VACUUM CHAMBERS
Language Note: English
Notes:
In its First NASA Workshop on Wiring for Space Applications p 125-131 (SEE N95-16044 04-20)

TITLE: ***Auroral interactions with ISSA***

Document ID: **19950010447** N (95N16862) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106794 E-9258 NAS 1.15:106794
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:

Purvis, Carolyn K. (NASA Lewis Research Center) Snyder, David B. (NASA Lewis Research Center) Jongeward, Gary A. (Maxwell Labs., Inc.)

Published: Dec 01, 1994
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 20
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE

Abstract:

Due to its high inclination orbit, International Space Station Alpha (ISSA) will occasionally experience surface charging by the high energy electrons of the auroral environment. This study looks at the frequency of these occurrences and recapitulates a charging model. ISSA should expect about 80 auoral encounters annually. If the plasma contactor is not run continuously, the vehicle may charge several hundred volts. Charge storage on standard space station coatings should not be a problem, but care must be taken that materials are not introduced inadvertently that cannot bleed off accumulated charge in a reasonable time. A conductivity requirement may be used to ensure surface materials do not charge to high voltages, or store charge for long periods of time.

Major Subject Terms:
ATTITUDE (INCLINATION) AURORAS HIGH ENERGY ELECTRONS HIGH VOLTAGES INTERNATIONAL SPACE STATION PLASMAS (PHYSICS) PREDICTION ANALYSIS TECHNIQUES SPACECRAFT CHARGING SURFACE PROPERTIES
Minor Subject Terms:
CONTACTORS MATHEMATICAL MODELS POLAR REGIONS SPATIAL DISTRIBUTION
Language Note: English

TITLE: ***Spacecraft environments interactions: Protecting against the effects of spacecraft charging***

Document ID: **19950013364** N (95N19780) **File Series**: NASA Technical Reports
Report Number: NASA-RP-1354 M-767 NAS 1.61:1354
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Herr, J. L. (Sverdrup Technology, Inc.) Mccollum, M. B. (NASA Marshall Space Flight Center)
Published: Nov 01, 1994
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 21
Contract Number: None
NASA Subject Category: SPACECRAFT DESIGN, TESTING AND PERFORMANCE
Abstract:
The effects of the natural space environments on spacecraft design, development, and operation are the topic of a series of NASA Reference Publications currently being developed by the Electromagnetics and Environments Branch, Systems Analysis and Integration Laboratory, Marshall Space Flight Center. This primer, second in the series, describes the interactions between a spacecraft and the natural space plasma. Under certain environmental/spacecraft conditions, these interactions result in the phenomenon known as spacecraft charging. It is the focus of this publication to describe the phenomenon of spacecraft charging and its possible adverse effects on spacecraft and to present the key elements of a Spacecraft Charging Effects Protection Plan.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS RADIATION EFFECTS RADIATION PROTECTION SPACE PLASMAS SPACECRAFT CHARGING
Minor Subject Terms:
ARC DISCHARGES COMPUTERIZED SIMULATION ELECTRIC CHARGE SPACECRAFT DESIGN
Language Note: English

TITLE: ***Parasitic current collection by solar arrays in LEO***

Document ID: **19950014111** N (95N20527) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:
Davis, Victoria A. (Maxwell Labs., Inc.) Gardner, Barbara M. (Maxwell Labs., Inc.)
Journal Title: NASA. Lewis Research Center, Proceedings of the 13th Space Photovoltaic Research and Technology Conference (SPRAT 13) **Page**: p 227-235
Published: Sep 01, 1994
Corporate Source:
Maxwell Labs., Inc. (San Diego, CA, United States)
Pages: 9
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
Solar cells at potentials positive with respect to a surrounding plasma collect electrons. Current is collected by the exposed high voltage surfaces: the interconnects and the sides of the solar cells. This current is a drain on the array power that can be significant for high-voltage arrays. In addition, this current influences the current balance that determines the floating potential of the spacecraft. One of the objectives of the Air Force (PL/GPS) PASP Plus experiment is an improved understanding of parasitic current collection. As part of the PASP Plus program, we are using computer modeling to improve our understanding of the physical processes that control parasitic current collection.
Major Subject Terms:
COLLECTION CURRENT DISTRIBUTION EARTH ORBITAL ENVIRONMENTS ENERGY DISSIPATION SOLAR ARRAYS SOLAR CELLS
Minor Subject Terms:
COMPUTERIZED SIMULATION ELECTRIC POTENTIAL ENERGY GAPS (SOLID STATE) PLASMAS (PHYSICS)
Language Note: English
Notes:
In NASA. Lewis Research Center, Proceedings of the 13th Space Photovoltaic Research and Technology Conference (SPRAT 13) p 227-235 (SEE N95-20502 06-33)
Sponsored by AF Materiel Command

TITLE: ***Preliminary results from the flight of the Solar Array Module Plasma Interactions Experiment (SAMPIE)***

Document ID: **19950014113** N (95N20529) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04
Authors:
Ferguson, Dale C. (NASA Lewis Research Center) Hillard, G. Barry (NASA Lewis Research Center)
Journal Title: Proceedings of the 13th Space Photovoltaic Research and Technology Conference (SPRAT 13) **Page**: p 247-256
Published: Sep 01, 1994
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 10
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
SAMPIE, the Solar Array Module Plasma Interactions Experiment, flew in the Space Shuttle Columbia payload bay as part of the Office of Aeronautics and Space Technology-2 (OAST-2) mission on STS-62, March, 1994. SAMPIE biased samples of solar arrays and space power materials to varying potentials with respect to the surrounding space plasma, and recorded the plasma currents collected and the arcs which occurred, along with a set of plasma diagnostics data. A large set of high quality data was obtained on the behavior of solar arrays and space power materials in the space environment. This paper is the first report on the data SAMPIE telemetered to the ground during the mission. It will be seen that the flight data promise to help determine arcing thresholds, snapover potentials, and floating potentials for arrays and spacecraft in LEO.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTRIC ARCS PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS SPACE PLASMAS SPACEBORNE EXPERIMENTS SPACECRAFT CONSTRUCTION MATERIALS SPACECRAFT POWER SUPPLIES
Minor Subject Terms:
ELECTRICAL FAULTS PLASMA CURRENTS PLASMA DIAGNOSTICS SPACE SHUTTLE PAYLOADS SPACE STATION POWER SUPPLIES
Language Note: English
Notes:
In its Proceedings of the 13th Space Photovoltaic Research and Technology Conference (SPRAT 13) p 247-256 (SEE N95-20502 06-33)

TITLE: ***Electrostatic noise in the plasma environment around the shuttle***

Document ID: **19950014771** N (95N21188) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106856 E-9447 NAS 1.15:106856 AIAA PAPER 95-1944
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A01

Authors:

Vayner, Boris V. (NASA Lewis Research Center) Ferguson, Dale C. (NASA Lewis Research Center)

Published: Feb 01, 1995
Corporate Source:

NASA Lewis Research Center (Cleveland, OH, United States)

Pages: 9
Contract Number: None
NASA Subject Category: GEOPHYSICS

Abstract:

The Langmuir probe flown as part of the Solar Array Module Plasma Interactions Experiment (SAMPIE) package aboard the space shuttle flight STS-62 was used to determine plasma potential fluctuations in the vicinity of the shuttle. The broadband noise was observed at frequencies 250 - 20,000 Hz. Measurements were performed in ram conditions; thus, it seems reasonable to believe that the influence of spacecraft operations on plasma parameters was absolutely negligible. The average spectrum of fluctuations is in agreement with theoretical predictions. The influence on the observed spectra of arcing generated by high negative bias voltages applied to solar cell samples is briefly discussed.

Major Subject Terms:

EARTH ORBITAL ENVIRONMENTS ELECTROSTATIC PROBES ELECTROSTATICS PLASMA DENSITY PLASMA JETS PLASMA POTENTIALS SPACE PLASMAS

Minor Subject Terms:

ELECTRON ENERGY PLASMA FREQUENCIES PLASMA INTERACTIONS PLASMA TEMPERATURE PLASMA TURBULENCE SOLAR CELLS SPECTRUM ANALYSIS

Language Note: English
Notes:

Presented at the 26th Plasmadynamics and Lasers Conference, San Diego, CA, 19-22 Jun. 1995; sponsored by AIAA

Plasmadynamics and Lasers Conference San Diego, CA 19-22 Jun. 1995

TITLE: ***Electromagnetic radiation in the plasma environment around the shuttle***

Document ID: **19950016699** N (95N23116) **File Series**: NASA Technical Reports
Report Number: NASA-TM-106891 E-9533 NAS 1.15:106891
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Vayner, Boris V. (NASA Lewis Research Center) Ferguson, Dale C. (NASA Lewis Research Center)
Published: Mar 01, 1995
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 21
Contract Number: None
NASA Subject Category: GEOPHYSICS
Abstract:
As part of the SAMPIE (The Solar Array Module Plasma Interaction Experiment) program, the Langmuir probe (LP) was employed to measure plasma characteristics during the flight STS-62. The whole set of data could be divided into two parts: (1) low frequency sweeps to determine voltage-current characteristics and to find electron temperature and number density; (2) high frequency turbulence (HFT dwells) data caused by electromagnetic noise around the shuttle. The broadband noise was observed at frequencies 250-20,000 Hz. Measurements were performed in ram conditions; thus, it seems reasonable to believe that the influence of spacecraft operations on plasma parameters was minimized. The average spectrum of fluctuations is in agreement with theoretical predictions. According to purposes of SAMPIE, the samples of solar cells were placed in the cargo bay of the shuttle, and high negative bias voltages were applied to them to initiate arcing between these cells and surrounding plasma. The arcing onset was registered by special counters, and data were obtained that included the amplitudes of current, duration of each arc, and the number of arcs per one experiment. The LP data were analyzed for two different situations: with arcing and without arcing. Electrostatic noise spectra for both situations and theoretical explanation of the observed features are presented in this report.
Major Subject Terms:
EARTH ORBITAL ENVIRONMENTS ELECTROMAGNETIC NOISE ELECTROMAGNETIC RADIATION ELECTROSTATIC PROBES PLASMA DENSITY PLASMA INTERACTIONS SPACE PLASMAS SPACE SHUTTLES
Minor Subject Terms:
BIAS BROADBAND ELECTRIC ARCS ELECTRON ENERGY NOISE SPECTRA PLASMA FREQUENCIES PLASMA TEMPERATURE PLASMA TURBULENCE SOLAR CELLS SPECTRUM ANALYSIS
Language Note: English
Notes:
Presented at the Chapman Conference on Measurement Techniques for Space Plasma, Santa Fe, NM, 3-7 Apr. 1995; sponsored by the American Geophysical Union
Chapman Conference on Measurement Techniques for Space Plasma Santa Fe, NM 3-7 Apr. 1995

TITLE: ***Arcing mitigation and predictions for high voltage solar arrays***

Document ID: 19950022779 N (95N29200) **File Series**: NASA Technical Reports
Report Number: AD-A292227 PL-TR-94-2233 SR-1
Sales Agency & Price: CASI Hardcopy A05 CASI Microfiche A01
Authors:
Mong, Renee L. (Massachusetts Inst. of Tech.) **Soldi**, James D., Jr. (Massachusetts Inst. of Tech.) Hastings, Daniel E. (Massachusetts Inst. of Tech.)
Published: Jul 26, 1994
Corporate Source:
Massachusetts Inst. of Tech. (Cambridge, MA, United States)
Pages: 81
Contract Number: F19628-92-K-0016
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
Future solar arrays are being designed for much higher voltages in order to meet high power demands at low currents. Unfortunately, negatively biased high voltage solar cells have been observed to arc when exposed to the low earth orbit plasma environment. Analytical and numerical models of this arcing phenomenon on conventional solar cells have been developed which show excellent agreement with experimental data. With an understanding of a mechanism for arcing, it is possible to determine methods of arc rate mitigation and to predict arc rates for experiments. Of the various arc rate mitigation methods examined in this research, decreasing the ratio of coverglass/adhesive dielectric constants and overhanging the coverglass show the most promise in reducing or even eliminating arcing. In addition, arcing rates were predicted for the high voltage biased arrays of the Air Force's Photovoltaic Array Space Power Plus Diagnostics experiment (PASP Plus). These predictions provide both expectations for the mission and a means to test the numerical and analytical models in the space environment for different solar cell technologies. Finally, a numerical model of the arc initiation process was also developed for wrap-through-contact cells.
Major Subject Terms:
ELECTRIC ARCS HIGH VOLTAGES LOW CURRENTS PERFORMANCE PREDICTION PHOTOVOLTAIC EFFECT PREDICTION ANALYSIS TECHNIQUES SOLAR ARRAYS SOLAR CELLS SOLAR WIND
Minor Subject Terms:
AEROSPACE ENVIRONMENTS BIAS ELECTRIC POTENTIAL LOW EARTH ORBITS MATHEMATICAL MODELS MILITARY OPERATIONS PERMITTIVITY
Language Note: English

TITLE: ***Arcing predictions for PASP PLUS solar arrays***

Document ID: 19950022780 N (95N29201) **File Series**: NASA Technical Reports
Report Number: AD-A292230 PL-TR-94-2234 SR-2
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01
Authors:
Soldi, James D., Jr. (Massachusetts Inst. of Tech.) Hastings, Daniel E. (Massachusetts Inst. of Tech.)
Published: Aug 02, 1994
Corporate Source:
Massachusetts Inst. of Tech. (Cambridge, MA, United States)
Pages: 49
Contract Number: F19628-92-K-0016
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
Future solar arrays are being designed for much higher voltages in order to meet high power demands at low currents. Unfortunately, negatively biased high voltage solar arrays have been observed to arc when exposed to the low earth orbit plasma environment. In previous work, analytical and numerical models of this arcing phenomenon on conventional solar cells have been developed which show excellent agreement with experimental data. The analytical model has been further developed to be more physically accurate and to be able to realistically model space experiments which will be operating in a widely changing environment. With this model, predictions were made for the solar array arcing on the upcoming Air Force Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) experiment. These simulations predict arcing rates ranging from 0 to 4.3 arcs/second, depending on the array and the experimental and environmental conditions. It was found that the cell thickness plays a dominant role in relative arc rates between the various cells. The large simulated database generated was used to develop software that will he used to examine and analyze the flight data, extracting correlations between arc rate and the various material properties, environmental variables, and operational parameters.
Major Subject Terms:
COMPUTER PROGRAMS ELECTRIC ARCS ELECTRIC POTENTIAL HIGH VOLTAGES LOW CURRENTS PHOTOVOLTAIC EFFECT SOLAR ARRAYS SOLAR CELLS SOLAR WIND SPACEBORNE EXPERIMENTS
Minor Subject Terms:
BIAS COMPUTERIZED SIMULATION CORRELATION DATA BASES LOW EARTH ORBITS MATHEMATICAL MODELS MILITARY OPERATIONS THICKNESS
Language Note: English

TITLE: ***Operating in the space plasma environment: A spacecraft charging study of the Solar X-ray Imager***

Document ID: **19950024047** N (95N30468) **File Series**: NASA Technical Reports
Report Number: NASA-TM-110644 NAS 1.15:110644
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A01
Authors:
Herr, Joel L. (Sverdrup Technology, Inc.) Mccollum, Matthew B. (NASA Marshall Space Flight Center) James, Bonnie F. (NASA Marshall Space Flight Center)
Published: Jan 01, 1994
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL, United States)
Pages: 6
Contract Number: None
NASA Subject Category: PLASMA PHYSICS
Abstract:
This study presents the results of a spacecraft charging effects protection study conducted on the Solar X-ray Imager (SXI). The SXI is being developed by NASA Marshall Space Flight Center for NOAA's Space Environment Laboratory, and will be used to aid in forecasting energetic particle events and geomagnetic storms. Images will provide information on the intensity and location of solar flares, coronal mass ejections, and high speed solar streams. The SXI will be flown on a next-generation GOES sometime in the mid to late 1990's. Charging due to the encounter with a worst-case magnetic substorm environment is modeled using the NASCAP/GEO computer code. Charging levels of exterior surfaces and the floating potential of the spacecraft relative to plasma are determined as a function of spacecraft design, operational configuration, and orbital conditions. Areas where large surface voltage gradients exist on or near the SXI are identified as possible arc-discharge sites. Results of the charging analysis are then used to develop design recommendations that will limit the effects of spacecraft charging on the SXI operation.
Major Subject Terms:
AEROSPACE ENVIRONMENTS ARC DISCHARGES SPACE PLASMAS SPACECRAFT CHARGING SPACECRAFT DESIGN X RAY TELESCOPES
Minor Subject Terms:
ELECTRIC POTENTIAL ENERGETIC PARTICLES GOES SATELLITES SOLAR CORPUSCULAR RADIATION SOLAR FLARES SOLAR X-RAYS STELLAR MASS EJECTION X RAY IMAGERY
Language Note: English

TITLE: ***Observations of ionosphere heating in the TSS-1 subsatellite presheath***

Document ID: **19950033444** A (95A65043) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Katz, Ira (S-Cubed Division of Maxwell Laboratories, San Diego, CA) Melchioni, Enrico (Consiglio Nazionale delle Richerche) Mandell, Myron (S-Cubed Division of Maxwell Laboratories, San Diego, CA) Oberhardt, Marilyn (Phillips Laboratory, Hanscom AFB, MA) Thompson, Don (Utah State Univ.) Neubert, Torsten (Univ. of Michigan, Ann Arbor, MI) Gilchrist, Brian (Univ. of Michigan, Ann Arbor, MI) Bonifazi, Carlo (Agenzia Spaziale Italiana)
Journal Title: Journal of Geophysical Research **Page**: p. 8961-8969
Published: May 01, 1994
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 9
Contract Number: None
NASA Subject Category: GEOPHYSICS
Abstract:
The first flight of the Tethered Satellite System (TSS-1) was to investigate the mechanical and electrical dynamics of a conducting satellite deployed from the orbiter via a tether whose core was a conducting wire. In the TSS-1 system the satellite deployed from the orbiter radially away from the Earth. The relative motion between the tether and Earth's magnetic field generated an electromotive force (EMF) that is the product of orbiter velocity, Earth's magnetic field, and the length of the deployed tether. This EMF drove a current through the tether. Electrons were collected on the satellite's electrically conductive skin and traveled through the tether to the orbiter, where they either went to orbiter structural ground or were emitted into the ionosphere via active eletron emission. During TSS-1 this electron emission was accomplished mainly by the 100 mA, 1-KeV fast pulsed electron gun (FPEG) of the shuttle electrodynamic tether system (SETS). The FPEG electron emission was much higher than either ambient ion collection at the orbiter end or electron collection at the satellite. Potentials of the orbiter with respect to the ambient plasma were obtained from measurements from the Shuttle Potential and Return Electron Experiment (SPREE), the SETS tether current voltage monitor (Thompson et al., 1993), and the Agenzia Spaziale Italiana deployer and satellite core equipment. Despite the limited tether deployment length of 268 m the TSS-1 system proved capable, during certain events, of generating satellite potentials sufficient to illuminate a previously unexplored aspect of plasma physics: that of an ion repelling, electron attracting, moving probe in a magnetoplasma. During such events the satellite boom-mounted Langmuir probe flown as a part of the Research on Electrodynamic Tethers experiment measured an increase in the electron plasma temperature in the quasi-neutral ionospheric region beyond the satellite sheath. This observed heating of the presheath electrons was distinctly different from the acceleration of the elctrons in the sheath, which was also observed when the sheath expanded such that the probe was completely in the sheath. We show that the observed elevated electron temperatures are consistent with the formation of a Bohm stable electron collecting sheath.
Major Subject Terms: ELECTRODYNAMICS ELECTRON PLASMA ELECTROSTATIC PROBES IONOSPHERIC HEATING PLASMA HEATING PLASMA SHEATHS TETHERED SATELLITES
Minor Subject Terms:
DATA REDUCTION GEOMAGNETISM PLASMA TEMPERATURE
Language Note: English
Notes: Journal of Geophysical Research vol 99, no. A5 p. 8961-8969 May 1, 1994
Research sponsored by the Air Force Materiel Command

TITLE: ***Arcing of negatively biased solar cells in a plasma environment***

Document ID: **19950038524** A (95A70123) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Upschulte, B. L. (Physical Sciences, Inc) Marinelli, W. J. Carleton, K. L. Weyl, G. Aifer, E. Hastings, D. E.
Journal Title: Journal of Spacecraft and Rockets **Volume**: 31 **Issue**: 3 **Page**: p. 493-501
Published: May 01, 1994
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 9
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
Experimental and theoretical efforts have been conducted to investigate the arcing of negatively biased solar arrays in a low-Earth orbit plasma environment. Experiments were conducted in an ultrahigh vacuum plasma test chamber, where the environment could be controlled carefully. Outgassing of the adhesive used to bind the protective coverglass to the solar cells was determined to be a key factor in observed arcing rates. These rates could be reduced by greater than a factor of 100 by eliminating or fully outgassing the excess adhesive remaining at the edge of the solar cells. Optical emission from solar cell arcs was observed to correlate linearly with arc current, both temporally and in total intensity. Solar cell arcing rates were also observed to scale linearly with plasma density. The plasma scaling is in good agreement with a theory based on enhanced field electron emission charging of dielectric surfaces, leading to enhanced electric fields at the conductor/adhesive/plasma triple junction. Apparent thresholds for solar cell arcing are reported.
Major Subject Terms:
ARC DISCHARGES EARTH ORBITAL ENVIRONMENTS ELECTRIC ARCS OUTGASSING SOLAR CELLS SPACE PLASMAS
Minor Subject Terms:
ADHESIVES ELECTRIC FIELDS FIELD EMISSION LIGHT EMISSION PLASMA DENSITY SOLAR ARRAYS VACUUM TESTS
Language Note: English
Notes:
Journal of Spacecraft and Rockets vol. 31, no. 3 p. 493-501 May-June 1994

TITLE: Plasma chamber testing of advanced photovoltaic solar array coupons

Document ID: 19950038531 A (95A70130) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hillard, G. Barry (NASA Lewis Research Center)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 31 **Issue**: 3 **Page**: p. 530-532
Published: May 01, 1994
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 3
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The solar array module plasma interactions experiment is a space shuttle experiment designed to investigate and quantify the high voltage plasma interactions. One of the objectives of the experiment is to test the performance of the Advanced Photovoltaic Solar Array (APSA). The material properties of array blanket are also studied as electric insulators for APSA arrays in high voltage conditions. Three twelve cell prototype coupons of silicon cells were constructed and tested in a space simulation chamber.
Major Subject Terms:
HIGH VOLTAGES PLASMA INTERACTIONS SOLAR ARRAYS SOLAR CELLS SPACE ENVIRONMENT SIMULATION
Minor Subject Terms:
INSULATORS SPACE PLASMAS SPACE SHUTTLE PAYLOADS SPACEBORNE EXPERIMENTS
Language Note: English
Notes:
Journal of Spacecraft and Rockets vol. 31, no. 3 p. 530-532 May-June 1994

TITLE: ***Measured plasma conductivity of zinc-oxide-based thermal control coatings***

Document ID: 19950041981 A (95A73580) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Hillard, G. Barry (NASA Lewis Research Center)
Journal Title: Journal of Spacecraft and Rockets **Volume**: 31 **Issue**: 5 **Page**: p. 910-912
Published: Sep 01, 1994
Corporate Source:
NASA Lewis Research Center (Cleveland, OH, United States)
Pages: 3
Contract Number: None
NASA Subject Category: GROUND SUPPORT SYSTEMS AND FACILITIES (SPACE)
Abstract:
The **plasma** conductivity of Z93 and Z93p thermal control coatings was measured directly in a space simulation chamber. For Z93P, the conductivity was found to be nearly constant 0.5 uS/sq m while in Z93, conductivity was approximately an order of magnitude larger and demonstrated a somewhat more pronounced dependence on voltage. The differences in the measured conductivity were accounted to the small differences in the composition of the binder between the two coatings.
Major Subject Terms:
CONCENTRATION (COMPOSITION) **CURRENT** DENSITY ENVIRONMENTAL TESTS **PLASMA** CONDUCTIVITY **PLASMA** CURRENTS PLASMAS (PHYSICS) TEST CHAMBERS THERMAL CONTROL COATINGS ZINC OXIDES
Minor Subject Terms:
BINDERS (MATERIALS) ELECTRIC POTENTIAL SPACE SIMULATORS THERMODYNAMIC PROPERTIES
Language Note: English
Notes:
Journal of Spacecraft and Rockets vol. 31, no. 5 p. 910-912 September-October 1994

TITLE: ***Parasitic current collection by PASP Plus solar arrays***

Document ID: **19960007907** N (96N15073) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Davis, Victoria Ann (Maxwell Labs., Inc.) Gardner, Barbara M. (Maxwell Labs., Inc.)
Journal Title: NASA. Lewis Research Center, Proceedings of the 14th Space Photovoltaic Research and Technology Conference (SPRAT 14) **Page**: p 40
Published: Oct 01, 1995
Corporate Source:
Maxwell Labs., Inc. (La Jolla, CA, United States)
Pages: 1
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:

Solar cells at potentials positive with respect to a surrounding plasma collect electrons. Current is collected by the exposed high voltage surfaces: the interconnects and the sides of the solar cells. This current is a drain on the array power that can be significant for high-power arrays. In addition, this current influences the current balance that determines the floating potential of the spacecraft. One of the objectives of the Air Force (PL/GPS) PASP Plus (Photovoltaic Array Space Power Plus Diagnostics) experiment is an improved understanding fo parasitic current collection. We have done computer modeling of parasitic current collection and have examined current collection flight data from the first year of operations. Prior to the flight we did computer modeling to improve our understanding of the physical processes that control parasitic current collection. At high potentials, the current rapidly rises due to a phenomenon called snapover. Under snapover conditions, the equilibrium potential distribution across the dielectric surface is such that part of the area is at potentials greater than the first crossover of the secondary yield curve. Therefore, each incident electron generates more than one secondary electron. The net effect is that the high potential area and the collecting area increase. We did two-dimensional calculations for the various geometries to be flown. The calculations span the space of anticipated plasma conditions, applied potential, and material parameters. We used the calculations and early flight data to develop an analytic formula for the dependence of the current on the primary problem variables. The analytic formula was incorporated into the EPSAT computer code. EPSAT allows us to easily extend the results to other conditions. PASP Plus is the principal experiment integrated onto the Advanced Photovoltaic and Electronics Experiments (APEX) satellite bus. The experiment is testing twelve different solar array designs. Parasitic current collection is being measured for eight of the designs under various operational and environment conditions. We examined the current collected as a function of the various parameters for the six non-concentrator designs. The results are similar to those obtained in previous experiments and predicted by the calculations. We are using the flight data to validate the analytic formula developed. The formula can be used to quantify the parasitic current collected. Anticipating the parasitic current value allows the spacecraft designer to include this interaction when developing the design.

Major Subject Terms:
APPLICATIONS PROGRAMS (COMPUTERS) ELECTRIC CURRENT FLIGHT TESTS MATHEMATICAL MODELS OHMIC DISSIPATION PHOTOVOLTAIC CONVERSION SATELLITE-BORNE INSTRUMENTS SOLAR ARRAYS SOLAR CELLS SPACEBORNE EXPERIMENTS SPACECRAFT POWER SUPPLIES
Minor Subject Terms: COMPUTATIONAL GEOMETRY COMPUTERIZED SIMULATION CONCENTRATORS NASA SPACE PROGRAMS PLASMA POTENTIALS RADIATION EFFECTS SPACE PLASMAS TWO DIMENSIONAL MODELS
Language Note: English
Notes: In NASA. Lewis Research Center, Proceedings of the 14th Space Photovoltaic Research and Technology Conference (SPRAT 14) p 40 (SEE N96-15042 03-20)
Sponsored in cooperation with Air Force Materiel Command

TITLE: ***High-voltage space-plasma interactions measured on the PASP Plus test arrays***

Document ID: **19960007908** N (96N15074) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity
Authors:
Guidice, Donald A. (Phillips Lab.)
Journal Title: NASA. Lewis Research Center, Proceedings of the 14th Space Photovoltaic Research and Technology Conference (SPRAT 14) **Page**: p 41
Published: Oct 01, 1995
Corporate Source:
Phillips Lab. (Hanscom AFB, MA, United States)
Pages: 1
Contract Number: None
NASA Subject Category: ENERGY PRODUCTION AND CONVERSION
Abstract:
The Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) experiment was developed by the Air Force's Phillips Laboratory with support from NASA's Lewis Research Center. It was launched on the Advanced Photovoltaic and Electronics EXperiments (APEX) satellite on August 3, 1994 into a 70 degree inclination, 363 km by 2550 km elliptical orbit. This orbit allows the investigation of space plasma effects on high-voltage operation (leakage current at positive voltages and arcing at negative voltages) in the perigee region. PASP Plus is testing twelve solar arrays. There are four planar Si arrays: an old standard type (used as a reference), the large-cell Space Station Freedom (SSF) array, a thin 'APSA' array, and an amorphous Si array. Next are three GaAs on Ge planar arrays and three new material planar arrays, including InP and two multijunction types. Finally, there are two concentrator arrays: a reflective-focusing Mini-Cassegrainian and a Fresnel-lens focusing Mini-Dome. PASP Plus's diagnostic sensors include: Langmuir probe to measure plasma density, an electrostatic analyzer (ESA) to measure the 30 eV to 30 KeV electron/ion spectra and determine vehicle negative potential during positive biasing, and a transient pulse monitor (TPM) to characterize the arcs that occur during the negative biasing. Through positive biasing of its test arrays, PASP Plus investigated the snapover phenomenon, which took place over the range of +100 to +300 V. It was found that array configurations where the interconnects are shielded from the space plasma (i.e., the concentrators or arrays with 'wrap-through' connectors) have lower leakage current. The concentrators exhibited negligible leakage current over the whole range up to +500 V. In the case of two similar GaAs on Ge arrays, the one with 'wrap-through' connectors had lower leakage current than the one with conventional interconnects. Through negative biasing, PASP Plus investigated the arcing rates of its test arrays. The standard Si array, with its old construction (exposed rough-surface interconnects), arced significantly over a wide voltage and plasma-density range. The other arrays arced at very low rates, mostly at voltages greater than -350 V and plasma densities near or greater than 10(exp 5)/cm(exp -3). AS expected according to theory, arcing was more prevalent when array temperatures were cold (based on biasing in eclipse).
Major Subject Terms:
ELECTRON ENERGY FLIGHT TESTS HIGH VOLTAGES PERFORMANCE TESTS PHOTOVOLTAIC CELLS PLASMA DENSITY RADIATION MEASUREMENT SATELLITE-BORNE INSTRUMENTS SOLAR ARRAYS SPACE PLASMAS SPACEBORNE EXPERIMENTS
Minor Subject Terms:
ELECTRIC POTENTIAL ELECTROSTATIC PROBES ENERGY SPECTRA FOCUSING FRESNEL LENSES GALLIUM ARSENIDES NASA SPACE PROGRAMS OHMIC DISSIPATION SCIENTIFIC SATELLITES
Language Note: English
Notes:
In NASA. Lewis Research Center, Proceedings of the 14th Space Photovoltaic Research and Technology Conference (SPRAT 14) p 41 (SEE N96-15042 03-20)

TITLE: ***ARC Rate Simulation and Flight Data Analysis for the Pasp Plus Experiment***

Document ID: 19960020455 N (96N24028) **File Series**: NASA Technical Reports
Report Number: PL-TR-95-2126
Sales Agency & Price: CASI Hardcopy A13   CASI Microfiche A03 - No Copyright
Authors:
Soldi, James D., Jr. (Massachusetts Inst. of Tech.)   Hastings, Daniel E. (Massachusetts Inst. of Tech.)
Published: Sep 01, 1995
Corporate Source:
Massachusetts Inst. of Tech. (Cambridge, MA United States)
Pages: 288
Contract Number: F19628-92-K-0016
NASA Subject Category: Spacecraft Instrumentation
Abstract:
As power demands continue to increase, spacecraft power system are being designed to operate at higher voltages. When operating at high negative voltage, however, arcing may occur on the solar cells. In this work, a model of the arcing process developed by Cho and Hastings was refined to be more physically accurate and to better simulate experiment operations. The modified computer simulation was then used to predict the arcing rates on the PASP Plus solar cells. Both the pre-flight and post-flight simulations showed good agreement with the flight data. The flight data was then analyzed to examine correlations between arc rates and the various material, environmental, and operational parameters. Arcing levels were found to depend strongly on the bias voltages, with the scalings suggested by the model proving to accurately relate the arcing rates on the different modules. Cell temperature and ion flux were also found to be important parameters. As expected, a critical temperature above which no arcing occurs was found to exist.
Major Subject Terms:
SOLAR CELLS   SPACECRAFT POWER SUPPLIES   SOLAR ARRAYS   HIGH VOLTAGES   COMPUTERIZED SIMULATION   MATHEMATICAL MODELS   ELECTRIC ARCS   OPERATING TEMPERATURE
Minor Subject Terms:
ELECTRIC CURRENT   BIAS   CRITICAL TEMPERATURE   TEMPERATURE DEPENDENCE   SPACEBORNE EXPERIMENTS   SCIENTIFIC SATELLITES   ELECTRON EMISSION   ION CHARGE   TIME DEPENDENCE   GALLIUM ARSENIDES   GROUND TESTS   PHOTOVOLTAIC CONVERSION   FLIGHT TESTS   DATA REDUCTION   FLIGHT SIMULATION
Language Note: English

TITLE: ***Arc Rate Simulation and Flight Data Analysis for the PASP Plus Experiment***

Document ID: 19960024017 N (96N26611) **File Series**: NASA Technical Reports
Report Number: AD-A301837 PL-TR-95-2126
Sales Agency & Price: CASI Hardcopy A13 CASI Microfiche A03 - No Copyright
Authors:
Soldi, James D., Jr. (Massachusetts Inst. of Tech.) Hastings, Daniel E. (Massachusetts Inst. of Tech.)
Published: Sep 01, 1995
Corporate Source:
Massachusetts Inst. of Tech. (Cambridge, MA United States)
Pages: 284
Contract Number: F19628-92-K-0016
NASA Subject Category: Aircraft Design, Testing and Performance
Abstract:
As power demands continue to increase, spacecraft power systems are being designed to operate at higher voltages. When operating at high negative voltages, however, arcing may occur on the solar cells. In this work, a model of the arcing process developed by Cho and Hastings was refined to be more physically accurate and to better simulate experiment operations. The modified computer simulation was then used to predict the arcing rates on the PASP Plus solar cells. Both the pre-flight and post-flight simulations showed good agreement with the flight data. The flight data was then analyzed to examine corelations between arc rates and the various material, environmental, and operational parameters. Arcing levels were found to depend strongly on the bias voltages, with the scalings suggested by the model proving to accurately relate the arcing rates on the dilferent modules. Cell temperature and ion flux were also found to be important parameters. As expected, a critical temperature above which no arcing occurs was found to exist. Solar array arcing, High voltage solar arrays, PASP Plus, Wrap-through-contact solar cells.
Major Subject Terms:
SPACECRAFT POWER SUPPLIES SOLAR CELLS ELECTRIC ARCS FLUX (RATE)
Minor Subject Terms:
ARC DISCHARGES COMPUTERIZED SIMULATION ELECTRIC POTENTIAL BIAS ION DENSITY (CONCENTRATION)
Language Note: English

TITLE: ***ISSA/TSS power preliminary design***

Document ID: **19960025459** N (96N27496) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04 - No Copyright
Authors:
Main, John A. (Vanderbilt Univ.)
Journal Title: Research Reports: 1995 NASA/ASEE Summer Faculty Fellowship Program
Published: Feb 01, 1996
Corporate Source:
Vanderbilt Univ. (Nashville, TN United States)
Pages: 8
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
A projected power shortfall during the initial utilization flights of the International Space Station Alpha (ISSA) has prompted an inquiry into the use of the Tethered Satellite System (TSS) to provide station power. The preliminary design of the combined ISSA/TSS system is currently underway in the Preliminary Design Office at the Marshall Space Flight Center. This document focuses on the justification for using a tether system on space station, the physical principles behind such a system, and how it might be operated to best utilize its capabilities. The basic components of a simple DC generator are a magnet of some type and a conductive wire. Moving the wire through the magnetic field causes forces to be applied to the electric charges in the conductor, and thus current is induced to flow. This simple concept is the idea behind generating power with space-borne tether systems. The function of the magnet is performed by the earth's magnetic field, and orbiting a conductive tether about the earth effectively moves the tether through the field.
Major Subject Terms:
INTERNATIONAL SPACE STATION TETHERED SATELLITES SPACE STATION POWER SUPPLIES GEOMAGNETISM ELECTRIC CONDUCTORS
Minor Subject Terms:
TETHERING DC GENERATORS
Language Note: English

TITLE: ***Electromagnetic radiation generated by arcing in low density plasma***

Document ID: **19960026754** N (96N28314) **File Series**: NASA Technical Reports
Report Number: NASA-TM-107217 NAS 1.15:107217 E-10244
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Vayner, Boris V. (NASA Lewis Research Center) Ferguson, Dale C. (NASA Lewis Research Center) Snyder, David B. (NASA Lewis Research Center) Doreswamy, C. V. (NASA Lewis Research Center)
Published: May 01, 1996
Corporate Source:
NASA Lewis Research Center (Cleveland,OH United States)
Pages: 34
Contract Number: None
NASA Subject Category: Plasma Physics
Abstract:
An unavoidable step in the process of space exploration is to use high-power, very large spacecraft launched into Earth orbit. Obviously, the spacecraft will need powerful energy sources. Previous experience has shown that electrical discharges occur on the surfaces of a high-voltage array, and these discharges (arcs) are undesirable in many respects. Moreover, any high voltage conductor will interact with the surrounding plasma, and that interaction may result in electrical discharges between the conductor and plasma (or between two conductors with different potentials, for example, during docking and extravehicular activity). One very important aspect is the generation of electromagnetic radiation by arcing. To prevent the negative influence of electromagnetic noise on the operation of spacecraft systems, it seems necessary to determine the spectra and absolute levels of the radiation, and to determine limitations on the solar array bias voltage that depend on the parameters of LEO plasma and the technical requirements of the spacecraft equipment. This report describes the results of an experimental study and computer simulation of the electromagnetic radiation generated by arcing on spacecraft surfaces. A large set of high quality data was obtained during the Solar Array Module Plasma Interaction Experiment (SAMPIE, flight STS-62) and ground test. These data include the amplitudes of current, pulse forms, duration of each arc, and spectra of plasma waves. A theoretical explanation of the observed features is presented in this report too. The elaborated model allows us to determine the parameters of the electromagnetic noise for different frequency ranges, distances from the arcing site, and distinct kinds of plasma waves.
Major Subject Terms:
ELECTROMAGNETIC RADIATION ELECTRIC ARCS ELECTROMAGNETIC NOISE LOW EARTH ORBITS SOLAR ARRAYS COMPUTERIZED SIMULATION PLASMA WAVES PLASMA-ELECTROMAGNETIC INTERACTION
Minor Subject Terms:
AEROSPACE VEHICLES EXTRAVEHICULAR ACTIVITY SPACECRAFT DOCKING LARGE SPACE STRUCTURES SPACECRAFT EQUIPMENT SPACE TRANSPORTATION SYSTEM GROUND TESTS PULSE DURATION PLASMA SPECTRA FREQUENCY RANGES SPACECRAFT POWER SUPPLIES ELECTRIC POTENTIAL PLASMA INTERACTION EXPERIMENT PLASMA CONDUCTIVITY
Language Note: English
Notes:
International Symposium on Discharges and Electrical Insulation in Vacuum Berkeley, CA 21-26 Jul. 1996

TITLE: ***Data analysis and model comparison for solar array module plasma interactions experiment***

Document ID: **19960028210** A (96A60006) **File Series**: Open Literature
Report Number: None
Sales Agency & Price: Issuing Activity - Copyright
Authors:
Perez De La Cruz, Carmen (Massachusetts Inst of Technology) Hastings, Daniel E. Ferguson, Dale Hillard, Barry
Journal Title: Journal of Spacecraft and Rockets **Volume**: 33 **Issue**: 3 **Page**: p. 438-446
Published: May 01, 1996
Corporate Source:
(Corporate Source(s) Not Available)
Pages: 9
Contract Number: None
NASA Subject Category: Energy Production and Conversion
Abstract:
Analysis of the Solar Array Module Plasma Interactions Experiment flight data from STS-62 was conducted to examine the relationships between the arc rate and the various solar-cell properties, environmental variables, and solar-cell parameters. The data indicate the existence of a critical ion flux, a critical neutral density, a threshold voltage for arcing to occur, and scaling of the arc rate with work function.
Major Subject Terms:
AEROSPACE SCIENCES FLUX (RATE) LOW EARTH ORBITS PLASMA INTERACTIONS PLASMAS (PHYSICS) SOLAR ARRAYS SOLAR CELLS THRESHOLD VOLTAGE
Minor Subject Terms:
ELECTRIC ARCS ELECTRIC DISCHARGES ELECTRIC FIELDS MATHEMATICAL MODELS
Language Note: English
Notes:
Journal of Spacecraft and Rockets, vol. 33, no. 3, p. 438-446, May-June 1996

TITLE: ***Magnetic field observations during the release experiments of the CRRES-LEO mission***

Document ID: **19960045324** N (96N72515) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity (Fachinformationszentrum (FIZ), Karlsruhe, Germany) - No Copyright
Authors:
Luehr, H. (Technische Univ.)
Published: Apr 01, 1994
Corporate Source:
Technische Univ. (Brunswick, Germany)
Pages: 30
Contract Number: BMFT-50OM8803
NASA Subject Category: Geophysics
Abstract:
Prime objective of the CRRES-LEO mission was the investigation of the interaction of two rapidly counter streaming plasmas. For the facilitation of these experiments, chemical releases were planned. The gas should be injected from a spacecraft at 400 km altitude creating a cloud that moves with the orbital velocity of 7.5 km/s relative to the background plasma. A complement of diagnostic instruments was selected, which should observe various plasma processes in-situ. Aim of the project reported here was the development and fabrication of a magnetometer for the diagnostic package. Unfortunately, the project was stopped by NASA, so the magnetometer development was terminated in the prototype stage. In addition to the hardware activity, we also worked on numerical simulations of chemical release experiments. Based on our experiences of the AMPTE mission, we modified our programs in such a a way that they fit the conditions during the CRRES mission.
Major Subject Terms:
MAGNETOHYDRODYNAMIC FLOW • SPACECRAFT INSTRUMENTS • MAGNETIC FIELDS • CHEMICAL CLOUDS • SPACE PLASMAS • SPACEBORNE EXPERIMENTS • MATHEMATICAL MODELS • CHEMICAL RELEASE MODULES
Minor Subject Terms:
CROSS FLOW • RESEARCH AND DEVELOPMENT • PROTOTYPES • GAS EXPANSION • EARTH ORBITAL ENVIRONMENTS • HARDWARE • SPACE MISSIONS • ORBITAL VELOCITY • IN SITU MEASUREMENT • CRRES (SATELLITE) • MAGNETOMETERS
Language Note: German

TITLE: ***Parasitic current collection by PASP Plus solar arrays***

Document ID: **19960045599** N (96N32502) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A03 - No Copyright
Authors:
Davis, Victoria A. (Maxwell Labs., Inc.) Gardner, B. M. (Maxwell Labs., Inc.) Guidice, Donald A. (Phillips Lab.) Severance, P. S. (Phillips Lab.)
Journal Title: Space Photovoltaic Research and Technology 1995 **Page**: 274-285
Published: Feb 01, 1996
Corporate Source:
Maxwell Labs., Inc. (San Diego, CA United States)
Pages: 12
Contract Number: None
NASA Subject Category: Energy Production and Conversion
Abstract:
Solar cells at potentials positive with respect to a surrounding plasma collect electrons. Current is collected by the exposed high voltage surfaces: the interconnects and the sides of the solar cells. This current is a drain on the array power that can be significant for high-power arrays. In addition, the current influences the current balance that determines the floating potential of the spacecraft. One of the objectives of the Air Force (PL/GPS) PASP Plus (Photovoltaic Array Space Power Plus Diagnostics) experiment is an improved understanding of parasitic current collection. We have done computer modelling of parasitic current collection and have examined current collection flight data from the first year of operations.
Major Subject Terms:
SOLAR CELLS SOLAR ARRAYS CURRENT DISTRIBUTION ELECTRIC CURRENT SPACEBORNE EXPERIMENTS SPACECRAFT POWER SUPPLIES OHMIC DISSIPATION APPLICATIONS PROGRAMS (COMPUTERS) FLIGHT TESTS
Minor Subject Terms:
SPACE PLASMAS HIGH VOLTAGES TRANSMISSION LOSS PLASMA TEMPERATURE PLASMA DENSITY ELECTRICAL MEASUREMENT MATHEMATICAL MODELS NASA SPACE PROGRAMS PLASMA POTENTIALS
Language Note: English

TITLE: ***High voltage space-plasma interactions measured on the PASP Plus test arrays***

Document ID: **19960045600** N (96N32503) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A03 - No Copyright
Authors:
Guidice, Donald A. (Phillips Lab.)
Journal Title: Space Photovoltaic Research and Technology 1995 **Page**: 286-295
Published: Feb 01, 1996
Corporate Source:
Phillips Lab. (Hanscom AFB, MA United States)
Pages: 10
Contract Number: None
NASA Subject Category: Composite Materials
Abstract:
The objectives of the PASP Plus experiment were as follows: to measure the plasma 'leakage' current for different kinds of arrays subjected to positive biasing levels up to +500 V; to measure the arcing parameters for different kinds of arrays subjected to negative biasing levels up to -500 V; and to measure the long-term deterioration in the power output of arrays using different solar-cell materials when exposed to space radiation. In all cases, the concept was to establish cause-and-effect relationships between array interactions and environmental conditions. Some of the positive and negative biasing results are discussed.
Major Subject Terms:
PLASMA CURRENTS SOLAR ARRAYS SOLAR CELLS HIGH VOLTAGES SPACE PLASMAS SPACEBORNE EXPERIMENTS PLASMA INTERACTIONS EXTRATERRESTRIAL RADIATION
Minor Subject Terms:
NASA SPACE PROGRAMS SILICON GALLIUM ARSENIDES TEMPERATURE DEPENDENCE COMPUTERIZED SIMULATION VOLT-AMPERE CHARACTERISTICS BIAS PLASMA DENSITY ELECTRICAL MEASUREMENT ELECTRIC ARCS ELECTRIC POTENTIAL
Language Note: English

TITLE: ***Low Frequency Waves in the Plasma Environment Around the Shuttle***

Document ID: **19970001715** N (97N11489) **File Series**: NASA Technical Reports
Report Number: NASA-TM-111723 NAS 1.15:111723
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Vayner, Boris V. (NASA Lewis Research Center) Ferguson, Dale C. (NASA Lewis Research Center)
Published: Jan 01, 1996
Corporate Source:
NASA Lewis Research Center (Cleveland, OH United States)
Pages: 41
Contract Number: None
NASA Subject Category: Plasma Physics
Abstract:
As a part of the SAMPIE (The Solar Array Module Plasma Interaction Experiment) program, the Langmuir probe (LP) was employed to measure plasma characteristics during the flight of STS-62. The whole set of data could be divided into two parts: (1) low frequency sweeps to determine voltage-current characteristics and to find the electron temperature and number density; (2) high frequency turbulence (HFT) data caused by electromagnetic noise around the Shuttle. Broadband noise was observed at 250-20,000 Hz frequencies. Measurements were performed in ram conditions; thus, it seems reasonable to believe that the influence of spacecraft operations on plasma parameters was minimized. It is shown that ion acoustic waves were observed, and two kinds of instabilities are suggested for explanation of the origin of these waves. According to the purposes of SAMPIE, samples of solar cells were placed in the cargo bay of the Shuttle, and high negative bias voltages were applied to them to initiate arcing between these cells and the surrounding plasma. The arcing onset was registered by special counters, and data were obtained that included the amplitudes of current, duration of each arc, and the number of arcs per one experiment. The LP data were analyzed for two different situations: with arcing and without arcing. Electrostatic noise spectra for both situations and a theoretical explanation of the observed features are presented in this paper.
Major Subject Terms:
ION ACOUSTIC WAVES PLASMA INTERACTION EXPERIMENT PLASMAS (PHYSICS) SPACE TRANSPORTATION SYSTEM SPACE SHUTTLES BAYS (STRUCTURAL UNITS) BROADBAND ELECTRIC POTENTIAL ELECTROMAGNETIC NOISE HIGH FREQUENCIES
Minor Subject Terms:
SOLAR ARRAYS SOLAR CELLS TURBULENCE NOISE SPECTRA
Language Note: English

TITLE: ***TSS-1R Failure Mode Evaluation***

Document ID: **19970021635 N** (97N22563) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A04 - No Copyright
Authors:
Vaughn, Jason A. (NASA Marshall Space Flight Center) McCollum, Matthew B. (NASA Marshall Space Flight Center) Kamenetzky, Rachel R. (NASA Marshall Space Flight Center)
Journal Title: Thirty-first Aerospace Mechanisms Symposium **Page**: 309-320
Published: May 01, 1997
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 12
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
Soon after the break of the tether during the Tethered Satellite System (TSS-1R) mission in February, 1996, a Tiger Team was assembled at the George C. Marshall Space Flight Center to determine the tether failure mode. One possible failure scenario was the Kevlar' strength member of the tether failed because of degradation due to electrical discharge or electrical arcing. During the next several weeks, extensive electrical discharge testing in low vacuum and plasma environments was conducted in an attempt to reproduce the electrical activity recorded by on-board science instruments during the mission. The results of these tests are presented in this paper.
Major Subject Terms:
TETHERING VACUUM TESTS TENSILE STRENGTH ARC DISCHARGES GROUND TESTS
Minor Subject Terms:
TETHERED SATELLITES LOW VACUUM PLASMAS (PHYSICS) ELECTRIC ARCS ELECTRIC POTENTIAL FAILURE ANALYSIS
Language Note: English

TITLE: ***Assessment of Corona/Arcing Hazard for Electron Beam Welding in Space Shuttle Bay at LEO for ISWE: Test Results***

Document ID: **19970005301** N (97N13227) **File Series**: NASA Technical Reports
Report Number: NASA-TM-108525 NAS 1.15:108525
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Nunes, A. C., Jr. (NASA Marshall Space Flight Center) Russell, C. (NASA Marshall Space Flight Center) Vaughn, J. (NASA Marshall Space Flight Center) Stocks, C. (NASA Marshall Space Flight Center) ODell, D. (NASA Marshall Space Flight Center) Bhat, B. (NASA Marshall Space Flight Center)
Published: Nov 01, 1996
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 12
Contract Number: None
NASA Subject Category: Mechanical Engineering
Abstract:
Test welds were made in argon over a range of pressures from 10-5 to 10-3 torr (the latter pressure an order of magnitude above pressures anticipated in the space shuttle bay during welding) with and without plasma on 304 stainless steel, 6Al-4V titanium, and 5456 aluminum in search of any possible unwanted electrical discharges. Only a faint steady glow of beam-excited atoms around the electron beam and sometimes extending out into the vacuum chamber was observed. No signs of current spiking or of any potentially dangerous electrical discharge were found.
Major Subject Terms:
ELECTRON BEAM WELDING ELECTRIC DISCHARGES ELECTRIC CORONA ELECTRON BEAMS PERFORMANCE TESTS
Minor Subject Terms:
STAINLESS STEELS TITANIUM ALLOYS VACUUM CHAMBERS ARGON SPACE SHUTTLES ARC DISCHARGES PRESSURE EFFECTS SPIKING LOW EARTH ORBITS HAZARDS
Language Note: English

TITLE: ***TSS-1R Mission Failure Investigation Board***

Document ID: **19970011947** N (97N16648) **File Series**: NASA Technical Reports
Report Number: NASA-TM-112426 NAS 1.15:112426
Sales Agency & Price: CASI Hardcopy A17 CASI Microfiche A03 - No Copyright
Authors:
Szalai, Kenneth J (NASA Dryden Flight Research Center) Bonifazi, Carlo (Italian Space Agency) Joyce, Paul M. (NASA Johnson Space Center) Schwinghamer, Robert J. (NASA Marshall Space Flight Center) White, Robert D. (NASA Johnson Space Center) Bowersox, Kenneth (NASA Johnson Space Center) Schneider, William C. (NASA Johnson Space Center) Stadler, John H. (NASA Langley Research Center) Whittle, David W. (NASA Johnson Space Center)
Published: May 03, 1996
Corporate Source:
NASA Dryden Flight Research Center (Edwards, CA United States)
Pages: 384
Contract Number: None
NASA Subject Category: Space Transportation
Abstract:
Reasons for the tether separation during the Tethered Satellite System (TSS-1) Mission are investigated. Lessons learned are presented.
Major Subject Terms:
TETHERED SATELLITES TETHERING FAILURE ANALYSIS POSTFLIGHT ANALYSIS CONTAMINATION COMPRESSION LOADS
Minor Subject Terms:
FAILURE MODES VIDEO DATA KEVLAR (TRADEMARK) CHARRING TENSILE STRENGTH ELECTRIC ARCS MANUFACTURING INSULATION COLUMBIA (ORBITER) HIGH VOLTAGES NASA SPACE PROGRAMS ELECTRODYNAMICS
Language Note: English

TITLE: ***Plasma Current Collection of Z-93 Thermal Paint***

Document ID: 19970015007 N (97N71276) **File Series**: NASA Technical Reports
Report Number: NASA-TM-112030 NAS 1.15:112030
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A01 - No Copyright
Authors:
Hillard, G. Barry (NASA Lewis Research Center)
Journal Title: Journal of Spacecraft and Rockets **Volume**: Volume 30 **Issue**: No. 6 **Page**: 767-769
Published: Dec 01, 1993
Publisher: American Inst. of Aeronautics and Astronautics
Corporate Source:
NASA Lewis Research Center (Cleveland, OH United States)
Pages: 4
Contract Number: None
NASA Subject Category: Nonmetallic Materials
Abstract:
The ability of Z-93 thermal control paint to conduct **current** from a simulated space **plasma** was measured directly in a space simulation chamber. For ions the collected **current** was found to be reduced by about a factor of three from that of metal. For electrons, currents were observed to be a factor of 50 smaller than metal at low voltages. The actual effect on Space Station Freedom cannot be determined without sophisticated modeling, which will proceed as part of the **plasma** contactor program, but from these results it is unlikely that surfaces coated with Z-93 will make any significant contribution to **plasma** contactor currents.
Major Subject Terms:
COATINGS CONTACTORS **PLASMA** CURRENTS TEMPERATURE CONTROL ELECTRIC POTENTIAL
Minor Subject Terms:
PLASMAS (PHYSICS) SIMULATION SPACE PLASMAS IONS
Language Note: English

TITLE: ***Survey of Experimental Results From One Year of PASP PLUS Orbital Operation***

Document ID: **19970018584** N (97N20522) **File Series**: NASA Technical Reports
Report Number: AD-A318286 PL-TR-96-2286
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Guidice, D. A. (Phillips Lab.) Curtis, H. B. (NASA Lewis Research Center) Piszczor, M. F. (NASA Lewis Research Center) Palys, J. R. (Boston Coll.)
Journal Title: 27th Plasmadynamicsand Lasers Conference
Published: Nov 14, 1996
Publisher: American Inst. of Aeronautics and Astronautics
Corporate Source:
Phillips Lab. (Hanscom AFB, MA United States)
Pages: 17
Contract Number: F19628-93-K-0019
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
With PASP Plus as its primary payload, the APEX satellite was launched by a standard Pegasus rocket released from a NASA B-52 aircraft on 3 August 1994. A 70 deg inclination, 363 km X 2550 km orbit was achieved, allowing both investigation of space plasma effects on high-voltage operation in the perigee region and investigation of space radiation effects on array power output from passage through the inner radiation belt in the apogee region. Data gathering by PASP Plus was begun on 7 Aug 94 and ended on 11 Aug 95. In one year, PASP Plus collected an order of magnitude more data on environmental interactions on solar arrays than all previous space-borne photovoltaic experiments combined. The test arrays flown and the interactions-measuring and space-environment sensors of PASP Plus are described. The results of measurements of leakage current under test-array positive biasing and arc rates under negative biasing as a function of bias voltage, plasma density, array orientation, and other conditions are presented. The results of measurements of test-array power-output degradation caused by space radiation are also examined.
Major Subject Terms:
SPACE PLASMAS SOLAR ARRAYS SATELLITE OBSERVATION RADIATION EFFECTS INNER RADIATION BELT EXTRATERRESTRIAL RADIATION PHOTOVOLTAIC EFFECT
Minor Subject Terms:
AEROSPACE ENVIRONMENTS PLASMA DENSITY RADIATION DOSAGE ELECTRIC POTENTIAL RADIATION HAZARDS
Language Note: English
Notes:
Plasmadynamics and Lasers New Orleans, LA 17-20 Jun. 1996

TITLE: ***TSS-1R Failure Mode Evaluation***

Document ID: **19970021635** N (97N22563) **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A04 - No Copyright
Authors:
Vaughn, Jason A. (NASA Marshall Space Flight Center) McCollum, Matthew B. (NASA Marshall Space Flight Center) Kamenetzky, Rachel R. (NASA Marshall Space Flight Center)
Journal Title: Thirty-first Aerospace Mechanisms Symposium **Page**: 309-320
Published: May 01, 1997
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 12
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
Soon after the break of the tether during the Tethered Satellite System (TSS-1R) mission in February, 1996, a Tiger Team was assembled at the George C. Marshall Space Flight Center to determine the tether failure mode. One possible failure scenario was the Kevlar' strength member of the tether failed because of degradation due to electrical discharge or electrical arcing. During the next several weeks, extensive electrical discharge testing in low vacuum and plasma environments was conducted in an attempt to reproduce the electrical activity recorded by on-board science instruments during the mission. The results of these tests are presented in this paper.
Major Subject Terms:
TETHERING VACUUM TESTS TENSILE STRENGTH ARC DISCHARGES GROUND TESTS
Minor Subject Terms:
TETHERED SATELLITES LOW VACUUM PLASMAS (PHYSICS) ELECTRIC ARCS ELECTRIC POTENTIAL FAILURE ANALYSIS
Language Note: English

TITLE: ***Atomic Oxygen Exposure of Power System and other Spacecraft Materials: Results of the EOIM-3 Experiment***

Document ID: **19970025577** N (97N25073) **File Series**: NASA Technical Reports
Report Number: NASA-TM-107427 NAS 1.15:107427 E-10673
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Morton, Thomas L. (NYMA, Inc.) Ferguson, Dale C. (NASA Lewis Research Center)
Published: May 01, 1997
Corporate Source:
NASA Lewis Research Center (Cleveland, OH United States)
Pages: 22
Contract Number: None
NASA Subject Category: Chemistry and Materials (General)
Abstract:
In order to test their reactivity with Atomic Oxygen, twenty five materials were flown on the EOIM-3 (Evaluation of Oxygen Interactions with Materials) portion of the STS-46 Mission. These materials include refractory metals, candidate insulation materials, candidate radiator coatings, and a selection of miscellaneous materials. This report documents the results of the pre- and post-flight analysis of these materials.
Major Subject Terms:
REFRACTORY METALS SPACE MISSIONS OXYGEN SURFACE REACTIONS SPACE TRANSPORTATION SYSTEM INSULATION REACTIVITY OXYGEN ATOMS
Minor Subject Terms:
EXPOSURE OXIDATION POSTFLIGHT ANALYSIS
Language Note: English

TITLE: ***Spacecraft Interactions Modeling and Post-Mission Data Analysis***

Document ID: **19970026082** N (97N25432) **File Series**: NASA Technical Reports
Report Number: AD-A325259 • RXR-96081 • PL-TR-96-2255
Sales Agency & Price: CASI Hardcopy A04 • CASI Microfiche A01 - No Copyright
Authors:
Bonito, N. A. (Radex, Inc.) • Bounar, K. H. (Radex, Inc.) • McNeil, W. J. (Radex, Inc.) • Roth, C. J. (Radex, Inc.) • Tautz, M. F. (Radex, Inc.) • Vancour, R. P. (Radex, Inc.)
Published: Aug 15, 1996
Corporate Source:
Radex, Inc. (Bedford, MA United States)
Pages: 72
Contract Number: F19628-93-C-0091
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
Software systems were designed and developed for data management, data acquisition, interactive visualization and analysis of solar arrays, tethered objects, and large object space plasma interactions. Simulations were performed and models were constructed for spacecraft interactions with the ambient environment. In Support of these analyses, models for satellite ephemeris, attitude determination, magnetic fields, atmospheric composition, and particle precipitation were designed and developed, using PL computational resources extensively. The SPREE experiments were two electrostatic analyzers and the SPREE Particle Correlator Experiment (SPACE) which were part of the Tethered Satellite System (TSS-1) on the STS46 Shuttle mission. During the TSS-1 Mission, SPREE was used to study the effects of a potential being induced between the tethered satellite and the by the motion of the conductive tether across Earth's magnetic field lines. These effects included investigations of return currents and wave-particle interactions. Subsequently, revisions and pre-mission testing was completed to support the TSS-lR experiment on STS-75. Calibration of the interaction of ion beams with the ambient plasma were studied for shuttle missions STS-6O and STS69. The MUMBO vacuum chamber measurements using the CALSYS system were analyzed. Methods and routines were developed to build calibration files which depict the average aperture response as a function of the polar and azimuth angles with respect to the aperture normal. The CHAWS experiment data was plotted and analyzed using the CHAPS, CHOMPS and CHUNKS programs.
Major Subject Terms:
COMPUTER PROGRAMS • GEOMAGNETISM • DATA ACQUISITION • DATA MANAGEMENT • SPACE MISSIONS • SOLAR ARRAYS • SPACE PLASMAS • SPACE TRANSPORTATION SYSTEM FLIGHTS
Minor Subject Terms:
MAGNETIC FIELDS • ELECTROSTATIC PROBES • PARTICLE PRECIPITATION • PLASMA INTERACTION EXPERIMENT • ATMOSPHERIC COMPOSITION • EPHEMERIDES • ION BEAMS • TETHERED SATELLITES • WAVE-PARTICLE INTERACTIONS
Language Note: English

TITLE: ***Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) Experiment***

Document ID: **19980017264 File Series**: NASA Technical Reports
Report Number: AD-A331959 PL-TR-97-1013
Sales Agency & Price: CASI Hardcopy A08 CASI Microfiche A02 - No Copyright
Authors:
Guidice, D. A. (Phillips Lab.) Davis, V. A. (Phillips Lab.) Curtis, H. B. (Phillips Lab.) Ferguson, D. C. (Phillips Lab.) Hastings, D. E. (Phillips Lab.)
Published: Mar 01, 1997
Corporate Source:
Phillips Lab. (Kirtland AFB, NM United States)
Maxwell Labs., Inc. (San Diego, CA United States)
Massachusetts Inst. of Tech. (Cambridge, MA United States)
Aerospace Corp. (Albuquerque, NM United States)
Pages: 156
Contract Number: None
NASA Subject Category: Spacecraft Propulsion and Power
Abstract:
The Photovoltaic Array Space Power Plus Diagnostics (PASP Plus) experiment flew on the Advanced Photovoltaic and Electronics Experiments (APEX) spacecraft and operated from August 1994 to June 1996. It collected information on parasitic current collection at high positive bias, negative potential arcing at high negative bias, and long-term radiation damage on 12 different solar cell technologies. This report summarizes the results from this experiment.
Major Subject Terms:
PHOTOVOLTAIC EFFECT SPACEBORNE EXPERIMENTS PHOTOVOLTAIC CELLS SOLAR ARRAYS
Minor Subject Terms:
SOLAR CELLS BIAS COLLECTION RADIATION DAMAGE DIAGNOSIS LONG TERM EFFECTS FLOW CHARTS CIRCUIT BOARDS
Language Note: English

TITLE: ***A Review of Scientific and Technological Results from the TSS-1R Mission***

Document ID: **19980202347 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A04 - No Copyright
Authors:

Stone, N. H. (NASA Marshall Space Flight Center) Wright, K. H. (Southwest Research Inst.) Winningham, J. D. (Southwest Research Inst.) Papadapolous, K. (Science Applications International Corp.) Zhang, T. X. (Alabama Univ.) Hwang, K. S. (Alabama Univ.) Wu, S. T. (Alabama Univ.) Samir, U. (Tel-Aviv Univ., Ramat-Aviv)

Journal Title: Tether Technology Interchange Meeting **Page**: 1-12
Published: Jan 01, 1998
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 12
Contract Number: None
NASA Subject Category: Astronautics (General)

Abstract:

The Tethered Satellite System (TSS) program was designed to provide a unique opportunity to explore certain space plasma-electrodynamic processes and the orbital mechanics of a gravity-gradient stabilized system of two satellites linked by a long conducting tether. A unique data set was obtained during deployment which has allowed significant science to be accomplished. This paper focuses on results from the TSS-1R mission that are most important to the future technological applications of electrodynamic tethers in space, in particular, the current collection process. Of particular significance is an apparent transition of the physics of current collection when the potential of the collecting body becomes greater than the ram energy of the ionospheric atomic oxygen ions. Previous theoretical models of current collection were electrostatic, assuming that the orbital motion of the system, which is highly subsonic with respect to electron thermal motion, was unimportant. This may still be acceptable for the case of relatively slow-moving sounding rockets. However, the TSS-1R results show that motion relative to the plasma must be accounted for in orbiting systems.

Major Subject Terms:
TETHERED SATELLITES SPACE PLASMAS ELECTRODYNAMICS GRAVITATION COLLECTION PARTICLE MOTION ELECTRIC CURRENT
Minor Subject Terms:
DEPLOYMENT ELECTRON MOBILITY ELECTROSTATICS MATHEMATICAL MODELS ORBITAL MECHANICS OXYGEN ATOMS OXYGEN IONS SOUNDING ROCKETS
Language Note: English

TITLE: ***Electron Flow to a Satellite at High Positive Potential***

Document ID: **19980206191 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04 - No Copyright
Authors:
Sheldon, John W. (Florida International Univ.)
Published: Oct 01, 1996
Corporate Source:
Florida International Univ. (Miami, FL United States)
Pages: 8
Contract Number: None
NASA Subject Category: Electronics and Electrical Engineering
Abstract:

The Tethered Satellite System (TSS) is designed to deploy a 1.6 m diameter spherical satellite a distance of 20 km above the space shuttle orbiter on an insulated conducting tether. Because of the passage of the conducting tether through the earth's magnetic field, an emf is generated producing a positive satellite potential of about 5000 V. Electron flow under the influence of this high positive potential is the focus of the present analysis. The ionospheric parameters at TSS orbit altitude are; thermal velocity of electrons, 1.9 x 10(exp 5) M/S, thermal velocity of the ions, 1.1 x 10(exp 3) m/s, velocity of the satellite 8 x 10(exp 3) m/s. The electrons, with a Debye length, lambda(D) = 0.49 cm, spiral about the earth's magnetic field lines (0.4 Gauss) with a radius of about 3 cm and the ions spiral with a radius of 5 m. Under these conditions, the electron thermal energy, kT is 0.17 eV. The TSS satellite radius, r(p) is 163 Debye lengths. There is an extensive literature on the interaction of satellites with the near-earth ionospheric plasma. The space charge limitation to the electron current collected by a sphere at positive electrical potential was calculated by Langmuir and Blodgett (1924). Parker and Murphy (1967) recognized the importance of the influence of the earth's magnetic field and used the guiding center approximation to calculate the electron current collected by a positive charged satellite. More recently Ma and Schunk (1989) have calculated the time dependent flow of electrons to a spherical satellite at positive potential utilizing numerical methods and Sheldon (1994) used similar methods to solve this problem for the steady state. In order to analyze some of the phenomena that occurred in the ionosphere during the TSS flights, it would be useful to have analytic expressions for these electron flows. The governing equations are very complex and an exact analytical solution is not likely. An approximate analytical solution is feasible however, and the results of one attempt are presented herein.

Major Subject Terms:

TETHERED SATELLITES • SPACE CHARGE • ELECTROMAGNETIC FIELDS • TETHERING • ELECTRON ENERGY • SPACE PLASMAS • GEOMAGNETISM • PARTICLE MOTION • MATHEMATICAL MODELS

Minor Subject Terms:

SPACE SHUTTLE ORBITERS • THERMAL ENERGY • DEBYE LENGTH • EARTH IONOSPHERE • IONOSPHERIC ELECTRON DENSITY

Language Note: English

TITLE: ***An Environment Monitoring Package for the International Space Station***

Document ID: **19990027920 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A01 - No Copyright
Authors:
Carruth, M. Ralph (NASA Marshall Space Flight Center) Clifton, Kenneth S. (NASA Marshall Space Flight Center)
Published: Jan 01, 1998
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 6
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
The first elements of the International Space Station (ISS) will soon be launched into space and over the next few years ISS will be assembled on orbit into its final configuration. Experiments will be performed on a continuous basis both inside and outside the station. External experiments will be mounted on attached payload locations specifically designed to accommodate experiments, provide data and supply power from ISS. From the beginning of the space station program it has been recognized that experiments will require knowledge of the external local environment which can affect the science being performed and may impact lifetime and operations of the experiment hardware. Recently an effort was initiated to design and develop an Environment Monitoring Package (EMP). This paper describes the derivation of the requirements for the EMP package, the type of measurements that the EMP will make and types of instruments which will be employed to make these measurements.
Major Subject Terms:
ENVIRONMENTAL MONITORING INTERNATIONAL SPACE STATION MASS SPECTROMETERS PRESSURE GAGES MICROBALANCES EARTH ORBITAL ENVIRONMENTS
Minor Subject Terms:
PAYLOADS MONATOMIC GASES OXYGEN ATOMS ULTRAVIOLET RADIATION PLASMA TURBULENCE ELECTROSTATIC PROBES
Language Note: English
Notes:
Space Technology and Applications Albuquerque, NM 31 Jan. - 4 Feb. 1999

TITLE: ***Geospace Magnetospheric Dynamics Mission***

Document ID: 19990042052 **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity Hardcopy Issuing Activity Microfiche - Copyright
Authors:
Russell, C. T. (California Univ.) Kluever, C. (Missouri Univ.) Burch, J. L. (Southwest Research Inst.) Fennell, J. F. (Aerospace Corp.) Hack, K. (NASA Lewis Research Center) **Hillard**, G. B. (NASA Lewis Research Center) Kurth, W. S. (Iowa Univ.) Lopez, R. E. (Maryland Univ.) Luhmann, J. G. (California Univ.) Martin, J. B. (NASA Goddard Space Flight Center) Hanson, J. E.
Journal Title: Science Closure and Enabling Technologies for Constellation Class Missions **Page**: 58-62
Published: Jan 01, 1998
Corporate Source:
NASA Lewis Research Center (Cleveland, OH United States)
Contract Number: None
NASA Subject Category: Geophysics
Abstract:
The Geospace Magnetospheric Dynamics (GMD) mission is designed to provide very closely spaced, multipoint measurements in the thin **current** sheets of the magnetosphere to determine the relation between small scale processes and the global dynamics of the magnetosphere. Its trajectory is specifically designed to optimize the time spent in the **current** layers and to minimize radiation damage to the spacecraft. Observations are concentrated in the region 8 to 40 R(sub E) The mission consists of three phases. After a launch into geostationary transfer orbit the orbits are circularized to probe the region between geostationary orbit and the magnetopause; next the orbit is elongated keeping perigee at the magnetopause while keeping the line of apsides down the tail. Finally, once apogee reaches 40 R(sub E) the inclination is changed so that the orbit will match the profile of the noon-midnight meridian of the magnetosphere. This mission consists of 4 solar electrically propelled vehicles, each with a single NSTAR thruster utilizing 100 kg of Xe to tour the magnetosphere in the course of a 4.4 year mission, the same thrusters that have been successfully tested on the Deep Space-1 mission.
Major Subject Terms:
RADIATION DAMAGE MAGNETOPAUSE ION PROPULSION **CURRENT** SHEETS APSIDES EARTH MAGNETOSPHERE
Minor Subject Terms:
TRANSFER ORBITS TRAJECTORIES SPACE MISSIONS PERIGEES NOON LAUNCHING ION ENGINES GEOSYNCHRONOUS ORBITS DEEP SPACE 1 MISSION
Language Note: English

TITLE: ***Electrical Breakdown of Anodized Structures in a Low Earth Orbital Environmental***

Document ID: **19990052584 File Series**: NASA Technical Reports
Report Number: NASA/TM-1999-209044 NAS 1.15:209044 E-11574
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Galofaro, J. T. (NASA Glenn Research Center) Doreswamy, C. V. (Tuskegee Inst.) Vayner, B. V. (Ohio Aerospace Inst.) Snyder, D. B. (NASA Glenn Research Center) Ferguson, D. C. (NASA Glenn Research Center)
Published: Apr 01, 1999
Corporate Source:
NASA Glenn Research Center (Cleveland, OH United States)
Pages: 14
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
A comprehensive set of investigations involving arcing on a negatively biased anodized aluminum plate immersed in a low density argon plasma at low pressures (P(sub O), 7.5 x 10(exp -5) Torr) have been performed. These arcing experiments were designed to simulate electrical breakdown of anodized coatings in a Low Earth Orbital (LEO) environment. When electrical breakdown of an anodized layer occurs, an arc strikes, and there is a sudden flux of electrons accelerated into the ambient plasma. This event is directly followed by ejection of a quasi-neutral plasma cloud consisting of ejected material blown out of the anodized layer. Statistical analysis of plasma cloud expansion velocities have yielded a mean propagation velocity, v = (19.4 3.5) km/s. As the plasma cloud expands into the ambient plasma, energy in the form of electrical noise is generated. The radiated electromagnetic noise is detected by means of an insulated antenna immersed in the ambient plasma. The purpose of the investigations is (1) to observe and record the electromagnetic radiation spectrum resulting from the arcing process. (2) Make estimates of the travel time of the quasi-neutral plasma cloud based on fluctuations to several Langmuir probes mounted in the ambient plasma. (3) To study induced arcing between two anodized aluminum structures in close proximity.
Major Subject Terms:
ANODIZING PLASMA HEATING SPACE PLASMAS ELECTROMAGNETIC NOISE ELECTROMAGNETIC RADIATION EARTH ORBITAL ENVIRONMENTS
Minor Subject Terms:
STATISTICAL ANALYSIS ARGON PLASMA LOW PRESSURE ENERGY TRANSFER SPECTRA
Language Note: English

TITLE: ***The Tethered Satellite System: Scientific and Technological Results***

Document ID: **19990064230 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity Hardcopy - Copyright
Authors:
Stone, Nobie H. (NASA Marshall Space Flight Center)
Published: Jan 01, 1997
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
The bi-national, US-Italian, Tethered Satellite System (TSS) program was designed to provide a unique opportunity to explore certain space plasma- electrodynamic processes and the orbital mechanics of a gravity-gradient stabilized system of two satellites linked by a long conducting tether. The second flight, TSS-LR, was launched February 22, 1996 on STS-75 and satellite deployment began at MET 3/00:27. A unique data set was obtained over the next five hours as the tether was deployed to a length of 19695 meters, which has allowed significant science to be accomplished. This presentation will focus on results from the TSS-LR mission that are most important to the future technological applications of electrodynamic tethers in space - in particular, the current collection process. Of particular significance is an apparent transition of the physics of current collection when the potential of the collecting body becomes greater than the ram energy of the ionospheric atomic oxygen ions. Previous theoretical models of current collection were electro- static - assuming that the orbital motion of the system, which is highly sub-sonic with respect to electron thermal motion, was unimportant. This may still be acceptable for the case of relatively slow-moving sounding rockets. However, the TSS-LR results show that motion relative to the plasma must be accounted for in orbiting systems.
Major Subject Terms:
TETHERED SATELLITES • SPACE PLASMAS • ELECTRODYNAMICS • GRAVITATION • PARTICLE MOTION • ORBITAL MECHANICS • MATHEMATICAL MODELS
Minor Subject Terms:
DEPLOYMENT • TETHERLINES • SPACE TRANSPORTATION SYSTEM • SOUNDING ROCKETS • OXYGEN IONS • OXYGEN ATOMS • GRADIENTS • ELECTRON MOBILITY
Language Note: English
Notes:
Turin Oct. 1997

TITLE: ***The TSS-1R Electrodynamic Tether Experiment: Scientific and Technological Results***

Document ID: **19990084046 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity Hardcopy - Copyright
Authors:
Stone, Nobie H. (NASA Marshall Space Flight Center) Raitt, W. J. (NASA Marshall Space Flight Center)
Published: Jan 01, 1998
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 1
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
The Tethered Satellite System (TSS) program was designed to provide the opportunity to explore certain space plasma-electrodynamic processes (associated with high-voltage bodies and electrical currents in space) and the orbital mechanics of a gravity-gradient stabilized system of two satellites linked by a long conducting tether. A unique data set was obtained during the TSS-1 R mission in which the tether emf and current reached values in excess of 3500 volts and 1 amp, respectively. The insight this has allowed into the current collection process and the physics of high-voltage plasma sheaths is significant. Previous theoretical models of current collection were electro-static assuming that the orbital motion of the system, which is highly sub-sonic with respect to electron thermal motion, was unimportant. This may still be acceptable for the case of relatively slow-moving sounding rockets. However, the TSS-1 R results show that motion relative to the plasma does affect current collection and must be accounted for in orbiting systems.
Major Subject Terms:
ELECTRON MOBILITY HIGH VOLTAGES SPACE PLASMAS TETHERED SATELLITES TETHERING ELECTRODYNAMICS ELECTRIC FIELDS ELECTRIC CURRENT
Minor Subject Terms:
MATHEMATICAL MODELS PLASMA SHEATHS
Language Note: English
Notes:
Advances in Space Research FROM Sep. 1999

TITLE: ***An Analysis of Closure Mechanisms in the Plasma Wake of the TSS-1R Satellite***

Document ID: **19990092495 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity Hardcopy - Copyright
Authors:
Stone, N. H. (NASA Marshall Space Flight Center) Wright, K. H. (Alabama Univ.) Samir, U. (Tel-Aviv Univ., Ramat-Aviv) Winningham, J. D. (Southwest Research Inst.)
Published: Jan 01, 1997
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 1
Contract Number: None
NASA Subject Category: Plasma Physics
Abstract:
Collisionless Plasma Expansion (CPE), also known as "plasma expansion into a vacuum," in its most fundamental form, is the process by which a plasma expands into a void, or region highly depleted of particles. In CPE, the expansion is driven by the highly mobile electron constituent of the plasma as it moves across the density gradient and into the void region. A bi-polar electric field is set up between this rapidly expanding electron front and the massive ions, which have a low thermal speed and lag behind in the region of the plasma-void interface. These ions are quickly accelerated by the expansion electric field and can, theoretically, approach the thermal speed of the electrons. CPE is a fundamental and a very robust process in that it only requires that a sharp density gradient exist in a plasma. It has already been observed to exist in various plasmas ranging over five orders of magnitude in density. The range of phenomena in which CPE has been observed includes the closure of plasma wakes created in simulated space plasmas in the laboratory; it was found to be the process controlling the refilling of the wake created by the Space Shuttle in the ionospheric plasma; and recent in situ data, obtained by the WIND spacecraft as it passed through the wake of the earth's moon last year, have shown CPE to be involved in the closure of the Lunar wake. CPE is also expected to influence the morphology and physics of the solar wind interactions with Mercury and Mars, and has been suggested as a potential factor in such wide ranging phenomena as the acceleration of plasma away from the coma of comets and the energization of ions that underlies the upward expansion of the polar wind into the earth's magnetosphere. The Tethered Satellite System (TSS)-1R data provides an opportunity to test this process in situ under semi-controlled conditions. The available data shows the intensity, drift energy and angle of inclination to the wake of the converging ion streams at a down stream distance of one satellite radius (80 CM).
Major Subject Terms:
COLLISIONLESS PLASMAS EARTH MAGNETOSPHERE ELECTRIC FIELDS PLASMA INTERACTIONS SOLAR WIND SPACE PLASMAS SOLAR TERRESTRIAL INTERACTIONS
Minor Subject Terms:
BIPOLARITY TETHERED SATELLITES
Language Note: English
Notes:
San Francisco, CA 8-12 Dec. 1997

TITLE: ***Interactive Spacecraft Charging Interactive Handbook with Integrated, Updated Spacecraft Charging Models***

Document ID: **19990097425 File Series**: NASA Technical Reports
Report Number: AIAA Paper 99-4594
Sales Agency & Price: Issuing Activity Hardcopy - Copyright
Authors:
Katz, I. (Maxwell Technologies, Inc.) Davis, V. A. (Maxwell Technologies, Inc.) Mandell, M. J. (Maxwell Technologies, Inc.) Gardner, B. M. (Maxwell Technologies, Inc.) Hilton, J. M. (Maxwell Technologies, Inc.) Minor, J. (NASA Marshall Space Flight Center) Fredrickson, A. R. (Jet Propulsion Lab., California Inst. of Tech.) Cooke, D. L. (Air Force Research Lab.)
Published: Sep 30, 1999
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 11
Contract Number: AFRL-11469
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
Recent spacecraft failures have brought into focus the need for increased understanding and modeling of spacecraft charging by spacecraft designers. Spacecraft charging assessments are needed for designing all geosynchronous, mid-altitude, and polar, low-earth orbit spacecraft. Under contract to the Spacecraft Environment Effects Program office at NASA/Marshall, we are developing a CD-ROM/web based multimedia interactive Spacecraft Charging Handbook with integrated, updated spacecraft charging models. This product guides the nonexpert through the appropriate analysis using the power of sophisticated charging analysis tools. It is easy to use and will be accessible over the web. Over three years, six assessment modeling tools are being developed and incorporated. We have completed the first year Environment, Material Properties, and Spacecraft Charging (Surface and Internal) tools. A Three-dimensional Surface Charging tool is under development. A Material Properties Database tool and an Auroral Charging tool remain to be developed.
Major Subject Terms:
SPACECRAFT CHARGING MODELS MULTIMEDIA COMPUTER GRAPHICS INTERACTIVE CONTROL HANDBOOKS
Minor Subject Terms:
SPACECRAFT ENVIRONMENTS ENVIRONMENT EFFECTS DATA BASES SOFTWARE DEVELOPMENT TOOLS SOFTWARE ENGINEERING
Language Note: English
Notes:
Space Technology Albuquerque, NM 28-30 Sep. 1999

TITLE: ***Development of an Environmental Monitoring Package for the International Space Station***

Document ID: **19990103148 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A01 - No Copyright
Authors:
Carruth, Ralph M., Jr. (NASA Marshall Space Flight Center) Clifton, Kenneth S. (NASA Marshall Space Flight Center) Vanhooser, Michael T. (NASA Marshall Space Flight Center)
Published: Jan 01, 1999
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 4
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
The first elements of the International Space Station (ISS) will soon be launched into space and over the next few years ISS will be assembled on orbit into its final configuration. Experiments will be performed on a continuous basis both inside and outside the station. External experiments will be mounted on attached payload locations specifically designed to accommodate experiments and provide data and power from ISS. From the beginning of the space station program it has been recognized that external experiments will require knowledge of the external environment because it can affect the science being performed and may impact lifetime and operations of the experiments. Recently an effort was initiated to design and develop an Environment Monitoring Package (EMP) was started. This paper describes the derivation of the requirements for the EMP package, the type of measurements that the EMP will make and types of instruments which will be employed to make these measurements.
Major Subject Terms:
ENVIRONMENTAL MONITORING INTERNATIONAL SPACE STATION
Minor Subject Terms:
CONTAMINANTS ELECTRIC POTENTIAL FLUX (RATE) PAYLOADS PLASMAS (PHYSICS) POSITION (LOCATION) VENTING CONTAMINATION OUTGASSING
Language Note: English
Notes:
Aerospace Sciences Reno, NV 11-14 Jan. 1999

TITLE: ***Analysis of Static Spacecraft Floating Potential at Low Earth Orbit (LEO)***

Document ID: **19990107364** **File Series**: NASA Technical Reports
Report Number: AIAA Paper 95-1943
Sales Agency & Price: Issuing Activity Hardcopy - Copyright
Authors:
Herr, Joel L. (Sverdrup Technology, Inc.) Hwang, K. S. (Computer Sciences Corp.) Wu, S. T. (Alabama Univ.)
Published: Jan 01, 1995
Corporate Source:
Sverdrup Technology, Inc. (Huntsville, AL United States)
Pages: 3
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:

Spacecraft floating potential is the charge on the external surfaces of orbiting spacecraft relative to the space. Charging is caused by unequal negative and positive currents to spacecraft surfaces. The charging process continues until the accelerated particles can be collected rapidly enough to balance the currents at which point the spacecraft has reached its equilibrium or floating potential. In low inclination. Low Earth Orbit (LEO), the collection of positive ion and negative electrons. in a particular direction. are typically not equal. The level of charging required for equilibrium to be established is influenced by the characteristics of the ambient plasma environment. by the spacecraft motion, and by the geometry of the spacecraft. Using the kinetic theory, a statistical approach for studying the interaction is developed. The approach used to study the spacecraft floating potential depends on which phenomena are being applied. and on the properties of the plasma. especially the density and temperature. The results from kinetic theory derivation are applied to determine the charging level and the electric potential distribution at an infinite flat plate perpendicular to a streaming plasma using finite-difference scheme.

Major Subject Terms:
ELECTRIC POTENTIAL FINITE DIFFERENCE THEORY KINETIC THEORY SPACE PLASMAS SPACECRAFT MOTION
Minor Subject Terms:
LOW EARTH ORBITS STATISTICAL ANALYSIS FLOATING
Language Note: English
Notes:
Plasmadynamics and Lasers San Diego, CA 19-22 Jun. 1995

TITLE: ***Satellite Particle Collection During Active States of the Tethered Satellite System (TSS)***

Document ID: **19990109095 File Series**: NASA Technical Reports
Report Number: AIAA Paper 96-2298
Sales Agency & Price: Issuing Activity Hardcopy - Copyright
Authors:
Wright, K. H., Jr. (Alabama Univ.) Stone, N. H. (NASA Marshall Space Flight Center) Winningham, J. D. (Southwest Research Inst.) Gurgiolo, C. (Southwest Research Inst.) Bonifazi, C. (Italian Space Agency) Gilchrist, B. (Michigan Univ.) Mariani, F. (Rome Univ.) Hardy, D. (Phillips Lab.)
Published: Jan 01, 1996
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 3
Contract Number: NAS8-37107
NASA Subject Category: Plasma Physics
Abstract:
The reflight of the Tethered Satellite System (TSS-1R) was carried aboard the Space Shuttle Columbia on February 22, 1996. After deploying a day later than planned, the satellite almost reached its full deployed distance before the tether broke. Data was collected for over 5 hours during deployment out to a distance of 19.7 km. Maximum emf attained during deployment was 3700 V while the maximum current achieved was just under 0.5 A. The current collected was factors of 2 to 4 greater than the predictions of the conventional Parker-Murphy theory. The microscopic view of the collection process at the satellite showed exotic behavior with the existence of 100 - 200 eV suprathermal electrons and significant spin phase modulation of the electron fluxes. Although the data set acquired from TSS- 1R was considerably less than planned, the quality of the data allows one of the main goals of the mission to be met--characterizing the system I-V response. A "quick look" assessment of the data has already shown that an understanding of the TSS-1R electrodynamic behavior will require modification of the standard picture of current collection in space plasmas
Major Subject Terms:
ELECTRODYNAMICS SPACE PLASMAS TETHERED SATELLITES
Minor Subject Terms:
SPACE SHUTTLES ELECTRONS
Language Note: English
Notes:
Plasmadynamics and Lasers New Orleans, LA 17-20 Jun. 1996

TITLE: ***The Conductor-Dielectric Junctions in a Low Density Plasma***

Document ID: **19990113111 File Series**: NASA Technical Reports
Report Number: NASA/TM-1999-209408 • E-11938 • NAS 1.15:209408
Sales Agency & Price: CASI Hardcopy A03 • CASI Microfiche A01 - No Copyright
Authors:

Vayner, Boris (Ohio Aerospace Inst.) • Galofaro, Joel (NASA Glenn Research Center) • Ferguson, Dale (NASA Glenn Research Center) • deGroot, Wim (DYNACS Engineering Co., Inc.) • Thomson, Clint (Utah State Univ.) • Dennison, J. R. (Utah State Univ.) • Davies, Robert (Utah State Univ.)

Published: Nov 01, 1999
Corporate Source:

NASA Glenn Research Center (Cleveland, OH United States)

Pages: 30
Contract Number: None
NASA Subject Category: Plasma Physics
Abstract:

A conductor-dielectric junction exposed to the space environment is a frequent spacecraft design feature. Due to spacecraft charging and/or solar array operation, the conductor can acquire a high potential with respect to the surrounding plasma. If this potential is positive the insulators adjacent to exposed conductors can collect current as if they were conductors themselves. This phenomenon, called snapover, results in a substantial increase in current collection, and may even result in a glow discharge if the potential is high enough. If a conductor has a negative potential, arcing can occur at the site of a junction. Both of these phenomena negatively affect spacecraft operation. To prevent negative consequences, the physical mechanisms of snapover and arc inception require investigation. In this paper, results are presented of an experimental and theoretical study of snapover, glow discharge, and arc phenomena for different materials immersed in argon or xenon plasmas. The effect of snapover is investigated for several metal-dielectric junctions: copper-teflon, copper-Kapton, copper-glass, aluminum-teflon, aluminum-Kapton, steel-teflon, anodized aluminum with pinholes, and copper-ceramics. I-V curves are measured and snapover inception voltages, essential parameters (increase in current and collection area due to secondary electrons), and glow discharge inception thresholds are determined. Optical spectra are obtained for glow discharges in both argon and xenon plasmas. These spectra provide information regarding atomic species entrapped in the glow region. Some spectral lines can be used to estimate plasma parameters in the discharge area. A video-camera and linear array were used to confirm that snapover inception is accompanied by very low intensity visible light emission. This result seems to be important for the estimate of the light pollution around spacecraft. Optical spectra (wavelengths 380-650 nm) of arcs are also obtained on a negatively biased chromic acid anodized aluminum plate immersed in low density argon and xenon plasmas. Analysis of these spectra confirms our earlier findings that aluminum atoms are ejected from the arc site. Moreover, it is found that chromium atoms are also quite abundant in the arc plasma. It is believed that the latter results contribute considerably to the understanding of processes of plasma contamination caused by arcing.

Major Subject Terms:

CONDUCTORS • DIELECTRICS • SOLAR ARRAYS • SPACECRAFT CHARGING • SPACECRAFT GLOW • SPACECRAFT DESIGN • GLOW DISCHARGES • LIGHT EMISSION • LINE SPECTRA • PLASMA INTERACTIONS • PLASMA JETS • PLASMAS (PHYSICS)

Minor Subject Terms:

ARGON PLASMA • XENON • ALUMINUM • COPPER • KAPTON (TRADEMARK) • TEFLON (TRADEMARK) • CERAMICS • GLASS

Language Note: English
Notes:

Aerospace Sciences Reno, NV 10-13 Jan. 2000

TITLE: ***Increasing Importance of Material Electrical Interaction with the Space Environment***

Document ID: **19990116192** **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity Hardcopy - No Copyright
Authors:
Carruth, M. R., Jr. (NASA Marshall Space Flight Center) • Vaughn, Jason (NASA Marshall Space Flight Center)
Published: Jan 01, 2000
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 1
Contract Number: None
NASA Subject Category: Electronics and Electrical Engineering
Abstract:
The electrical properties of materials have always been important for spacecraft in charging environments. However, in recent years consideration of interactions of materials and systems with the plasma environment has become more and more important in spacecraft design. This has primarily been driven by independent factors including increase in power and high voltage power systems, operation of tethered satellites, and science requirements for electrostatic clean spacecraft. Increased need for power has led to increased operating voltages for spacecraft. The Upper Atmospheric Research Satellite (UARS) was one of the first to operate at near 100 V solar array potential and demonstrate that the spacecraft floated nearly the entire voltage negative of the ionospheric plasma. The high voltage, 160 V, of the solar arrays on the International Space Station (ISS) led to the requirement to have a plasma contactor to control structure potential relative to the local plasma. Issues such as sputtering, dielectric breakdown, capacitive energy storage in the structure, space debris impact induced arcs and other arcing mechanisms had to be addressed. Recently commercial satellites, driven to higher voltages for efficiency, have experienced arcing problems which led to severe, permanent power degradation. The first tethered satellite, Tethered Satellite System (TSS), was deployed from the Space Shuttle. A conductive coating was developed which provided a low resistivity and also the required solar absorptivity and emittance. Other tether systems are being designed which will have similar requirements but also long life and "bare tether" designs are also being built for flight experiments. The wire requires an electrically conductive coating with proper thermal control properties, which a bare wire doesn't possess. Increasing sophistication of scientific instruments and measurements which scientists want to make have led to increasing requirements for conducting thermal control coatings to provide electrostatic cleanliness. These issues, which are increasing the importance of electrical interaction of materials to the space environment, will be discussed in this paper as well as research into material development to meet thermal and electrical requirements and research to understand phenomena regarding such interactions.
Major Subject Terms:
ELECTRICAL PROPERTIES • ELECTRIC POTENTIAL • AEROSPACE ENVIRONMENTS • SOLAR ARRAYS • INTERNATIONAL SPACE STATION • SPACE SHUTTLES
Minor Subject Terms:
ABSORPTIVITY • EMITTANCE • CAPACITORS • ENERGY STORAGE • THERMAL CONTROL COATINGS • CONTACTORS • TETHERED SATELLITES • COMMERCIAL SPACECRAFT • PLASMA-PARTICLE INTERACTIONS
Language Note: English
Notes:
International Symposium on Materials in a Space Environment Arcachon 8 Jun. 2000

TITLE: ***Inception of Snapover and Gas Induced Glow Discharges***

Document ID: **20000021586 File Series**: NASA Technical Reports
Report Number: NASA/TM-2000-209645 NAS 1.15:209645 E-11991
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Galofaro, J. T. (NASA Glenn Research Center) Vayner, B. V. (Ohio Aerospace Inst.) Degroot, W. A. (DYNACS Engineering Co., Inc.) Ferguson, D. C. (NASA Glenn Research Center) Thomson, C. D. (Utah State Univ.) Dennison, J. R. (Utah State Univ.) Davies, R. E. (Utah State Univ.)
Published: Jan 01, 2000
Corporate Source:
NASA Glenn Research Center (Cleveland, OH United States)
Pages: 14
Contract Number: None
NASA Subject Category: Plasma Physics
Abstract:
Ground based experiments of the snapover phenomenon were conducted in the large vertical simulation chamber at the Glenn Research Center (GRC) Plasma Interaction Facility (PIF). Two Penning sources provided both argon and xenon plasmas for the experiments. The sources were used to simulate a variety of ionospheric densities pertaining to a spacecraft in a Low Earth Orbital (LEO) environment. Secondary electron emission is believed responsible for dielectric surface charging, and all subsequent snapover phenomena observed. Voltage sweeps of conductor potentials versus collected current were recorded in order to examine the specific charging history of each sample. The average time constant for sample charging was estimated between 25 and 50 seconds for all samples. It appears that current drops off by approximately a factor of 3 over the charging time of the sample. All samples charged in the forward and reverse bias directions, demonstrated hysteresis. Current jumps were only observed in the forward or positive swept voltage direction. There is large dispersion in tile critical snapover potential when repeating sweeps on any one sample. The current ratio for the first snapover region jumps between 2 and 4.6 times, with a standard deviation less than 1.6. Two of the samples showed even larger current ratios. It is believed the second large snapover region is due to sample outgassing. Under certain preset conditions, namely at the higher neutral gas background pressures, a perceptible blue-green glow was observed around the conductor. The glow is believed to be a result of secondary electrons undergoing collisions with an expelled tenuous cloud of gas, that is outgassed from the sample. Spectroscopic measurements of the glow discharge were made in an attempt to identify specific lines contributing to the observed glow.
Major Subject Terms:
GLOW DISCHARGES GAS DISCHARGES PLASMA PHYSICS
Minor Subject Terms:
ARGON PLASMA XENON LOW EARTH ORBITS SECONDARY EMISSION DIELECTRICS EARTH ORBITAL ENVIRONMENTS OUTGASSING SPECTROSCOPY ELECTRIC POTENTIAL TIME CONSTANT LUMINESCENCE ANODIC COATINGS VACUUM CHAMBERS STATISTICAL ANALYSIS
Language Note: English

TITLE: ***The TSS-1R Electrodynamic Tether Experiment: Scientific and Technological Results***

Document ID: **20000025437 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A01 - No Copyright
Authors:
Stone, Nobie H. (NASA Marshall Space Flight Center) Raitt, John (Utah State Univ.)
Published: Jan 01, 1998
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 1
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
The bi-national, US-Italian, Tethered Satellite System (TSS) program was designed to provide a unique opportunity to explore certain space plasma- electrodynamic processes and the orbital mechanics of a gravity-gradient stabilized system of two satellites linked by a long conducting tether. The second flight, TSS-1R, was launched February 22, 1996 on STS-75 and satellite deployment began at MET 3/00:27. A unique data set was obtained over the next five hours, as the tether was deployed to a length of 19695 meters, which has allowed significant science to be accomplished. This presentation will focus on electrodynamic processes generated by the tether--in particular, the collection of electrical current from the ionospheric plasma. Of particular significance is an apparent transition of the physics of current collection when the potential of the collecting body becomes greater than the ram energy of the ionospheric atomic oxygen ions. Previous theoretical models of current collection were electrostatic--assuming that the orbital motion of the system, which is highly subsonic with respect to electron thermal motion, was un- important. This may still be acceptable for the case of relatively slow-moving sounding rockets. However, the TSS-1R results show that motion relative to the plasma must be accounted for in orbiting systems.
Major Subject Terms:
EXPERIMENTATION DATA ACQUISITION TETHERING ELECTRODYNAMICS PLASMAS (PHYSICS) PARTICLE MOTION MATHEMATICAL MODELS
Minor Subject Terms:
TETHERED SATELLITES SPACE TRANSPORTATION SYSTEM SPACE PLASMAS SOUNDING ROCKETS OXYGEN IONS OXYGEN ATOMS ORBITAL MECHANICS ELECTROSTATICS ELECTRON MOBILITY
Language Note: English
Notes:
FROM 18 Jul. 1998

TITLE: ***Parasitic Current Collection by Solar Arrays in LEO***

Document ID: **20000032836 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04 - No Copyright
Authors:
Davis, Victoria A. (Systems Science and Software) Gardner, Barbara M. (Systems Science and Software)
Journal Title: Proceedings of the 13th Space Photovoltaic Research and Technology Conference (SPRAT 13) **Page**: 227-235
Published: Sep 01, 1994
Corporate Source:
Systems Science and Software (San Diego, CA United States)
Pages: 9
Contract Number: None
NASA Subject Category: Energy Production and Conversion
Abstract:
Solar cells at potentials positive with respect to a surrounding plasma collect electrons. Current is collected by the exposed high voltage surfaces: the interconnects and the sides of the solar cells. This current is a drain on the array power that can be significant for high-voltage arrays. In addition, this current influences the current balance that determines the floating potential of the spacecraft. One of the objectives of the Air Force (PL/GPS) PASP Plus experiment is an improved understanding of parasitic current collection. As part of the PASP Plus program, we are using computer modeling to improve our understanding of the physical processes that control parasitic current collection.
Major Subject Terms:
COMPUTERIZED SIMULATION ELECTRIC CURRENT SOLAR CELLS PLASMAS (PHYSICS) ELECTRONS
Minor Subject Terms:
BALANCE DRAINAGE FLOATING GLOBAL POSITIONING SYSTEM HIGH VOLTAGES LOW EARTH ORBITS
Language Note: English

TITLE: ***Preliminary Results from the Flight of the Solar Array Module Plasma Interactions Experiment (SAMPIE)***

Document ID: **20000032838** **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A04 - No Copyright
Authors:
Ferguson, Dale C. (NASA Lewis Research Center) Hillard, G. Barry (NASA Lewis Research Center)
Journal Title: Proceedings of the 13th Space Photovoltaic Research and Technology Conference (SPRAT 13) **Page**: 247-256
Published: Sep 01, 1994
Corporate Source:
NASA Lewis Research Center (Cleveland, OH United States)
Pages: 10
Contract Number: None
NASA Subject Category: Energy Production and Conversion
Abstract:
SAMPIE, the Solar Array Module Plasma Interactions Experiment, flew in the Space Shuttle Columbia payload bay as part of the OAST-2 mission on STS-62, March, 1994. SAMPIE biased samples of solar arrays and space power materials to varying potentials with respect to the surrounding space plasma, and recorded the plasma currents collected and the arcs which occurred, along with a set of plasma diagnostics data. A large set of high quality data was obtained on the behavior of solar arrays and space power materials in the space environment. This paper is the first report on the data SAMPIE telemetered to the ground during the mission. It will be seen that the flight data promise to help determine arcing thresholds, snapover potentials and floating potentials for arrays and spacecraft in LEO.
Major Subject Terms:
SOLAR ARRAYS FLIGHT RECORDERS PLASMA INTERACTIONS EXPERIMENTATION SPACE PLASMAS PLASMA DIAGNOSTICS
Minor Subject Terms:
TELEMETRY SPACE TRANSPORTATION SYSTEM SPACE SHUTTLE PAYLOADS PLASMA CURRENTS LOW EARTH ORBITS FLOATING BIAS AEROSPACE ENVIRONMENTS
Language Note: English

TITLE: ***Parasitic Current Collection by PASP Plus Solar Arrays***

Document ID: **20000033736 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A03 - No Copyright
Authors:
Davis, V. A. (Systems Science and Software) Gardner, B. M. (Systems Science and Software) Guidice, D. A. (Phillips Lab.) Severance, P. S. (Phillips Lab.)
Journal Title: Space Photovoltaic Research and Technology 1995 **Page**: 274-285
Published: Oct 01, 1995
Corporate Source:
Systems Science and Software (San Diego, CA United States)
Pages: 12
Contract Number: None
NASA Subject Category: Spacecraft Propulsion and Power
Abstract:
Solar cells at potentials positive with respect to a surrounding plasma collect electrons. Current is collected by the exposed high voltage surfaces: the interconnects and the sides of the solar cells. This current is a drain on the array power that can be significant for high-power arrays. In addition, this current influences the current balance that determines the floating potential of the spacecraft. One of the objectives of the Air Force (PL/GPS) PASP Plus (Photovoltaic Array Space Power Plus Diagnostics) experiment is an improved understanding of parasitic current collection. We have done computer modeling of parasitic current collection and have examined current collection flight data from the first year of operations.
Major Subject Terms:
SOLAR CELLS SOLAR ARRAYS PHOTOVOLTAIC CELLS COMPUTERIZED SIMULATION ELECTRIC CURRENT ACCUMULATORS
Minor Subject Terms:
PLASMAS (PHYSICS) HIGH VOLTAGES GLOBAL POSITIONING SYSTEM FLOATING ELECTRONS DRAINAGE DIAGNOSIS
Language Note: English

TITLE: ***High Voltage Space-Plasma Interactions Measured on the PASP Plus Test Arrays***

Document ID: **20000033737** **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A02 CASI Microfiche A03 - No Copyright
Authors:
Guidice, D. A. (Phillips Lab.)
Journal Title: Space Photovoltaic Research and Technology 1995 **Page**: 286-295
Published: Oct 01, 1995
Corporate Source:
Phillips Lab. (Hanscom AFB, MA United States)
Pages: 10
Contract Number: None
NASA Subject Category: Spacecraft Propulsion and Power
Abstract: Space systems of the late 1990s and beyond will require more efficient space-power sources. In providing electrical power for these new systems, consideration must be given to operating photovoltaic subsystems at higher voltage levels to minimize I(exp 2) R losses and/or reduce cable weight. New solar-cell materials are being developed for higher efficiency and less susceptibility to space radiation. Before using these new technologies on operational spacecraft, various environmental interactions questions must be answered by investigations in the actual space environment. The Photovoltaic Array pace Power Plus Diagnostics (PASP Plus) experiment was developed and flown for this purpose. In early 1990, the Air Force's Space Test Program (STP) offered PASP Plus a flight on a satellite put into orbit by a Pegasus launch vehicle. PASP Plus was to be part of the APEX (Advanced Photovoltaic and Electronics Experiments) mission, set up to fly it and two small "radiation effects on electronics" experiments, CRUX/CREDO and FERRO. To make PASP Plus suitable for APEX, a controller with increased functional capability and reduced weight was developed by Amptek, Inc. with the help of NASA Lewis personnel, twelve test arrays were mounted to the payload shelf and one of the deployed panels of the APEX satellite. Diagnostics sensors were incorporated into the experiment. PASP Plus successfully completed all functional and environmental testing, including "one sun simulated" thermal-vacuum tests at the Boeing facility at Kent, WA to give us preflight "array performance vs. temperature" characteristics for later comparison with flight data. The experiment was delivered to Orbital Sciences Corp. (OSC) for integration into APEX in July 1992. The APEX satellite was launched by a standard Pegasus rocket released from a NASA B-52 aircraft (based at Edwards AFB) on 3 August 1994 within the Western Test Range off the coast of California. The release from the B-52, the three stages of rocket firing, the satellite's lock-on to the sun, and the extension of its four deployable panels all occurred without problems. A 70 deg-inclination, 363 km x 2550 km orbit was achieved, satisfying PASP Plus's data-collecting requirements. The objectives of the PASP Plus experiment were: (a) To measure the plasma "leakage" current for different kinds of arrays subjected to positive biasing levels up to +500 V. (b) To measure the arcing parameters for different kinds of arrays subjected to negative biasing levels up to -500 V. and (c) To measure the long-term deterioration in the power output of arrays using different solar-cell materials when exposed to space radiation. In all cases, the concept was to establish cause-and-effect relationships between array interactions and environmental conditions. This paper will discuss some of the positive and negative biasing results; another paper at this conference will discuss the space radiation-induced deterioration aspects of the experiment.
Major Subject Terms: DATA ACQUISITION DETERIORATION DIAGNOSIS ELECTRIC POTENTIAL PANELS PHOTOVOLTAIC CELLS PLASMA INTERACTION EXPERIMENT SOLAR ARRAYS SOLAR CELLS
Minor Subject Terms: AEROSPACE ENVIRONMENTS AEROSPACE SYSTEMS B-52 AIRCRAFT CONTROLLERS DEPLOYMENT EXTRATERRESTRIAL RADIATION HIGH VOLTAGES LAUNCH VEHICLES PAYLOADS TEST RANGES
Language Note: English

TITLE: ***High Voltage Design Concepts for Launch Vehicles and Orbital Spacecraft Applications***

Document ID: 20000067650 File Series: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity - No Copyright
Authors:
Hall, David K. (NASA Marshall Space Flight Center)   Kirkici, Hulya (NASA Marshall Space Flight Center)   **Hillard**, G. Barry (NASA Glenn Research Center)   Schweickart, Daniel (Department of the Air Force)   Dunbar, Bill (Dunbar (Bill))
Published: Jan 01, 2000
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 1
Contract Number: None
NASA Subject Category: Launch Vehicles and Launch Operations
Abstract:
With the advent of design **concepts** such as, electromechanical actuation and "more electric" initiatives, has come the need for electrical power buses and electronic equipment to operate at higher than normal dc voltages to meet power requirements while keeping current levels to manageable levels. This new bus voltage has been typically 270 Volts dc nominal for launch vehicles, and 120 Volt dc for the International Space Station. This paper will discuss the new design applications for high voltage dc power in existing and future launch vehicles and spacecraft and the potential problems associated therewith. These new applications must be operational from lift-off, ascent, on orbit and descent in all of the pressure and temperature conditions for each, i.e. through the "Paschen region" twice. This paper will also attempt to stimulate an interest in the academic and professional communities to support and conduct research needed for design data applicable to high voltage dc usage.
Major Subject Terms:
HIGH VOLTAGES   LAUNCH VEHICLES   SPACECRAFT ORBITS   DESIGN ANALYSIS   TECHNOLOGY UTILIZATION   DIRECT CURRENT
Minor Subject Terms:
ACTUATORS   ELECTROMECHANICAL DEVICES   ELECTRONIC EQUIPMENT   ELECTRIC POTENTIAL
Language Note: English
Notes:
High Voltage Newport Beach, CA 10-12 Apr. 2000

TITLE: ***Overview of Advanced Space Propulsion Activities in the Space Environmental Effects Team at MSFC***

Document ID: **20000073215 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity - No Copyright
Authors:
Edwards, David (NASA Marshall Space Flight Center) Carruth, Ralph (NASA Marshall Space Flight Center) Vaughn, Jason (NASA Marshall Space Flight Center) Schneider, Todd (NASA Marshall Space Flight Center) Kamenetzky, Rachel (NASA Marshall Space Flight Center) Gray, Perry (Native American Services)
Published: Jan 01, 2000
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 1
Contract Number: None
NASA Subject Category: Spacecraft Propulsion and Power
Abstract:
Exploration of our solar system, and beyond, requires spacecraft velocities beyond our current technological level. Technologies addressing this limitation are numerous. The Space Environmental Effects (SEE) Team at the Marshall Space Flight Center (MSFC) is focused on three discipline areas of advanced propulsion; Tethers, Beamed Energy, and Plasma. This presentation will give an overview of advanced propulsion related activities in the Space Environmental Effects Team at MSFC. Advancements in the application of tethers for spacecraft propulsion were made while developing the Propulsive Small Expendable Deployer System (ProSEDS). New tether materials were developed to meet the specifications of the ProSEDS mission and new techniques had to be developed to test and characterize these tethers. Plasma contactors were developed, tested and modified to meet new requirements. Follow-on activities in tether propulsion include the Air-SEDS activity. Beamed energy activities initiated with an experimental investigation to quantify the momentum transfer subsequent to high power, 5J, ablative laser interaction with materials. The next step with this experimental investigation is to quantify non-ablative photon momentum transfer. This step was started last year and will be used to characterize the efficiency of solar sail materials before and after exposure to Space Environmental Effects (SEE). Our focus with plasma, for propulsion, concentrates on optimizing energy deposition into a magnetically confined plasma and integration of measurement techniques for determining plasma parameters. Plasma confinement is accomplished with the Marshall Magnetic Mirror (M3) device. Initial energy coupling experiments will consist of injecting a 50 amp electron beam into a target plasma. Measurements of plasma temperature and density will be used to determine the effect of changes in magnetic field structure, beam current, and gas species. Experimental observations will be compared to predictions from computer modeling.
Major Subject Terms:
AEROSPACE ENVIRONMENTS SOLAR SYSTEM SPACECRAFT PROPULSION MAGNETIC EFFECTS
Minor Subject Terms:
BEAM CURRENTS PLASMAS (PHYSICS) TETHERING PLASMA TEMPERATURE POWER BEAMING MAGNETIC FIELD CONFIGURATIONS
Language Note: English
Notes:
11th Advanced Propulsion Workshop Pasadena, CA 31 May - 2 Jun. 2000

TITLE: ***Development of an Electrostatically Clean Solar Array Panel***

Document ID: **20000091533 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright

Authors:
Stern, Theodore G. (Composite Optics, Inc.) Krumweide, Duane (Composite Optics, Inc.) Gaddy, Edward (NASA Goddard Space Flight Center) Katz, Ira (Maxwell Technologies, Inc.)

Published: Jan 01, 2000
Corporate Source:
NASA Goddard Space Flight Center (Greenbelt, MD United States)
Pages: 22
Contract Number: NAS5-99236
NASA Subject Category: Energy Production and Conversion

Abstract:
The results of design, analysis, and qualification of an Electrostatically Clean Solar Array (ECSA) panel are described. The objective of the ECSA design is to provide an electrostatic environment that does not interfere with sensitive instruments on scientific spacecraft. The ECSA design uses large, ITO-coated coverglasses that cover multiple solar cells, an aperture grid that covers the intercell areas, stress-relieved interconnects for connecting the aperture grid to the coverglasses, and edge clips to provides an electromagnetically shielded enclosure for the solar array active circuitry. Qualification coupons were fabricated and tested for photovoltaic response, conductivity, and survivability to launch acoustic and thermal cycling environments simulating LEO and GEO missions. The benefits of reducing solar panel interaction with the space environment are also discussed.

Major Subject Terms:
ELECTROSTATICS SOLAR ARRAYS PANELS DESIGN ANALYSIS AEROSPACE ENVIRONMENTS
Minor Subject Terms:
SOLAR CELLS LOW EARTH ORBITS PROTOTYPES PERFORMANCE TESTS FEASIBILITY ANALYSIS GEOSYNCHRONOUS ORBITS
Language Note: English

TITLE: ***ISS And Space Environment Interactions Without Operating Plasma Contactor***

Document ID: **20000093801 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity - No Copyright
Authors:
Carruth, M. R., Jr. (NASA Marshall Space Flight Center) Ferguson, Dale (NASA Glenn Research Center) Suggs,Rob (NASA Marshall Space Flight Center) McCollum, Matt (NASA Marshall Space Flight Center)
Published: Jan 11, 2001
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 3
Contract Number: None
NASA Subject Category: Spacecraft Propulsion and Power
Abstract:
The International Space Station (ISS) will be the largest, highest power spacecraft placed in orbit. Because of this the design of the electrical power system diverged markedly from previous systems. The solar arrays will operate at 160 V and the power distribution voltage will be 120 V. The structure is grounded to the negative side of the solar arrays so under the right circumstances it is possible to drive the ISS potential very negative. A plasma contactor has been added to the ISS to provide control of the ISS structure potential relative to the ambient plasma. The ISS requirement is that the ISS structure not be greater than 40 V positive or negative of local plasma. What are the ramifications of operating large structures with such high voltage power systems? The application of a plasma contactor on ISS controls the potential between the structure and the local plasma, preventing degrading effects. It is conceivable that there can be situations where the plasma contactor might be non-functional. This might be due to lack of power, the need to turn it off during some of the build-up sequences, the loss of functionality for both plasma contactors before a replacement can be installed, similar circumstances. A study was undertaken to understand how important it is to have the contactor functioning and how long it might be off before unacceptable degradation to ISS could occur. The details of interaction effects on spacecraft have not been addressed until driven by design. This was true for ISS. If the structure is allowed to float highly negative impinging ions can sputter exposed conductors which can degrade the primary surface and also generate contamination due to the sputtered material. Arcing has been known to occur on solar arrays that float negative of the ambient plasma. This can also generate electromagnetic interference and voltage transients. Much of the ISS structure and pressure module surfaces exposed to space is anodized aluminum. The anodization thickness is very thin to provide the required solar absorptance and emittance. For conditions where ISS structure can charge negative a large percentage of the array voltage, the dielectric strength of this layer is low, and dielectric breakdown (arcing) can occur. The energy stored capacitively in the structure can be delivered to the arc. The mechanisms by which this energy is delivered and how much of the energy is available hasn't been fully quantified. Questions have been raised regarding the possibility of whether a sustained arc might result due to current collected by the solar arrays from local plasma. It was postulated that even if dielectric breakdown didn't occur, impacts due to micrometeoroids and space debris could penetrate thin layers of dielectric on ISS and initiate an arc due to the coupling provided by the dense local plasma produced by the impact. This was proven in experiments conducted jointly by MSFC and Auburn University. A target chamber with a simulated ionospheric plasma and a biased, anodized aluminum plate and a 1-microfarad capacitor was used. The plate was then impacted by 75-micron particles accelerated to orbital velocity. Arc discharges were sustained for higher voltages but a threshold appears below which no discharge was initiated. Most items without an exposed power system will float electrically near the local plasma potential. This is true of the Space Shuttle, an Astronaut on EVA, and similar items. The structure of ISS might be at a large negative voltage. Therefore, capacitively stored energy can be transferred during docking, installing external boxes and equipment and Astronaut contact with ISS structure. The circumstances of when this can happen and the resulting effects are evaluated in this study. Also, a crewmember on EVA might be in the vicinity of an arc. All safety aspects of such an encounter including charging, molten particles from the arc site and EMI have been evaluated. This paper will report on the total results of this study focussed on the 4A configuration, scheduled to be complete in November,

2000. Interactions such as arcing, debris induced arcs, sustained arcs, sputtering, contamination from sputtering and arcing, docking interactions and Astronaut safety issues will all be addressed.

Major Subject Terms:

ARC DISCHARGES • SPACE DEBRIS • INTERNATIONAL SPACE STATION • STRUCTURAL ANALYSIS • PLASMA CONTROL • MICROMETEOROIDS • DEGRADATION • CONTAMINATION

Minor Subject Terms:

AEROSPACE ENVIRONMENTS • ALUMINUM • ANODIZING • CAPACITORS • CONDUCTORS • HIGH VOLTAGES • IMPINGEMENT • FLOATS • DENSE PLASMAS

Language Note: English

Notes:

39th Aerospace Sciences Meeting and Exhibit Reno, NV 8-11 Jan. 2001

NASA STI Help Desk
E-mail: help@sti.nasa.gov
Phone: 301-621-0390 FAX: 301-621-0134

TITLE: ***Satellite Motion Effects on Current Collection in Low Earth Orbit***

Document ID: **20000110580 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity - No Copyright
Authors:
Zhang, T. X. (Alabama Univ.) Hwang, K. S. (Chonnam National Univ.) Wu, S. T. (Alabama Univ.) Stone, N. H. (NASA Marshall Space Flight Center) Chang, C. L. (Science Applications International Corp.) Drobot, A. (Science Applications International Corp.) Wright, K. H., Jr. (Alabama Univ.)
Published: Jan 01, 2000
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 1
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
Results from the Tethered Satellite System (TSS) missions unambiguously show that the electrodynamic tether system produced 2 to 3 times the predicted current levels in the tether. The pre-mission predictions were based on the well-known Parker-Murphy (PM) model, which describes the collection of current by an electrically biased satellite in the ionospheric plasma. How the TSS satellite was able to collect 2-3 times the PM current has remained an open question. In the present study, self-consistent potential and motional effects are introduced into the Thompson and Dobrowolny sheath models. As a result, the magnetic field aligned sheath-an essential variable in determining current collection by a satellite-is derived and is shown to be explicitly velocity dependent. The orientation of the satellite's orbital motion relative to the geomagnetic field is also considered in the derivation and a velocity dependent expression for the collected current is obtained. The resulting model provides a realistic treatment of current collection by a satellite in low earth orbit. Moreover, the predictions, using the appropriate parameters for TSS, are in good agreement with the tether currents measured during the TSS-1R mission.
Major Subject Terms:
LOW EARTH ORBITS TETHERED SATELLITES ELECTRODYNAMICS ELECTRIC CURRENT GEOMAGNETISM
Minor Subject Terms:
VELOCITY DISTRIBUTION SATELLITE ORIENTATION SATELLITE ORBITS EARTH IONOSPHERE
Language Note: English

TITLE: ***ISS and Space Environment Interactions in Event of Plasma Contactor Failure***

Document ID: **20010020205** **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity - No Copyright
Authors:
Carruth, M. R., Jr. (NASA Marshall Space Flight Center)
Published: Jan 01, 2000
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 3
Contract Number: None
NASA Subject Category: Plasma Physics
Abstract:

The International Space Station (ISS), illustrated in Figure 1, will be the largest, highest power spacecraft placed in orbit. Because of this the design of the electrical power system diverged markedly from previous systems. The solar arrays will operate at 160 V and the power distribution voltage will be 120 V. The structure is grounded to the negative side of the solar arrays so under the right circumstances it is possible to drive the ISS potential very negative. A plasma contactor has been added to the ISS to provide control of the ISS structure potential relative to the ambient plasma. The ISS requirement is that the ISS structure not be greater than 40 V positive or negative of local plasma. What are the ramifications of operating large structures with such high voltage power systems? The application of a plasma contactor on ISS controls the potential between the structure and the local plasma, preventing degrading effects. It is conceivable that there can be situations where the plasma contactor might be non-functional. This might be due to lack of power, the need to turn it off during some of the build-up sequences, the loss of functionality for both plasma contactors before a replacement can be installed, and similar circumstances. A study was undertaken to understand how important it is to have the contactor functioning and how long it might be off before unacceptable degradation to ISS could occur.

Major Subject Terms:
SPACECRAFT CHARGING • SYSTEM GENERATED ELECTROMAGNETIC PULSES • ELECTRIC FIELDS • ELECTRIC CURRENT • SOLAR ARRAYS
Minor Subject Terms:
SPACE PLASMAS • CONTACTORS • INTERNATIONAL SPACE STATION • AEROSPACE ENVIRONMENTS
Language Note: English
Notes:
Spacecraft Charging Technology Noordwijk 23 - 27 Apr. 2001

TITLE: ***An Experimental Investigation of the Effects of Charging on the International Space Station***

Document ID: **20010021181 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity - No Copyright
Authors:
Schneider, Todd (NASA Marshall Space Flight Center) Carruth, M. Ralph (NASA Marshall Space Flight Center) Finckenor, Miria (NASA Marshall Space Flight Center) Vaughn, Jason (NASA Marshall Space Flight Center) Ferguson, Dale (NASA Glenn Research Center) Heard, John (Clarion Univ. of Pennsylvania)
Published: Jan 01, 2001
Corporate Source:
NASA Marshall Space Flight Center (Huntsville, AL United States)
Pages: 1
Contract Number: None
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:
An experimental investigation has been undertaken to determine the effects associated with operating the International Space Station (ISS) without a Plasma Contactor Unit (PCU). The role of the PCU is to maintain the potential of the ISS to within 40 volts of the ambient plasma potential. In the event of a PCU failure, ISS structure may charge to - 160 volts with respect to the Low Earth Orbit (LEO) plasma, due to the use of high voltage photovoltaic solar arrays. Operation without a PCU will result in the charging of the oxide layers on anodized aluminum components facing into the RAM direction. In this investigation, arcs were observed as a result of anodized materials charging in a plasma environment. Actual ISS materials were used in the investigation. The materials included meteoroid and debris shield samples, as well as components from the Extravehicular Mobility Unit (EMU). Results show that the occurrence of arcs was dependent on several factors including material composition and applied voltage. The breakdown thresholds for the materials tested will be shown, as well as the voltage and current waveforms during an arc event. The damage resulting from an arc will also be described. In addition, a description of associated operational hazards resulting from arcing on the spacecraft will be provided.
Major Subject Terms:
INTERNATIONAL SPACE STATION ELECTRIC POTENTIAL SPACE PLASMAS SPACE CHARGE
Minor Subject Terms:
PHOTOVOLTAIC CELLS
Language Note: English
Notes:
Spacecraft Charging Technology Noordwijk 23-27 Apr. 2001

TITLE: ***Hypervelocity Impact Studies on Solar Cell Modules***

Document ID: 20010056310 **File Series**: NASA Technical Reports
Report Number: AU-4-21839
Sales Agency & Price: CASI Hardcopy A02   CASI Microfiche A01 - No Copyright
Authors:
Brandhorst, Henry W., Jr. (Auburn Univ.)   Best, Stevie R. (Auburn Univ.)
Published: Mar 25, 2001
Corporate Source:
Auburn Univ. (AL United States)
Pages: 6
Contract Number: NAS3-99200
NASA Subject Category: Energy Production and Conversion
Abstract:
Space environmental effects have caused severe problems as satellites move toward increased power and operating voltage levels. The greatest unknown, however, is the effect of high velocity micrometeoroid impacts on high voltage arrays (200V). Understanding such impact phenomena is necessary for the design of future reliable, high voltage solar arrays, especially for Space Solar Power applications. Therefore, the objective of this work was to study the effect of hypervelocity impacts on high voltage solar arrays. Initially, state of the art, 18% efficient GaAs solar cell strings were targeted. The maximum bias voltage on a two-cell string was -200 V while the adjacent string was held at -140 V relative to the plasma potential. A hollow cathode device provided the plasma. Soda lime glass particles 40-120 micrometers in diameter were accelerated in the Hypervelocity Impact Facility to velocities as high as 11.6 km/sec. Coordinates and velocity were obtained for each of the approximately 40 particle impact sites on each shot. Arcing did occur, and both discharging and recharging of arcs between the two strings was observed. The recharging phenomena appeared to stop at approximately 66V string differential. No arcing was observed at 400 V on concentrator cell modules for the Stretched Lens Array.
Major Subject Terms:
HYPERVELOCITY IMPACT   SOLAR ARRAYS   ARC DISCHARGES
Minor Subject Terms:
MICROMETEOROIDS   IMPACT VELOCITY
Language Note: English

TITLE: ***Comparison of the NASCAP/GEO, POLAR, SEE Charging Handbook, and NASCAP-2K.1 Spacecraft Charging Codes***

Document ID: **20010059345 File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: Issuing Activity - No Copyright
Authors:

Neergaard, Linda E. (Sverdrup Technology, Inc.) Minow, Joseph (Sverdrup Technology, Inc.) McCollum, Matt (NASA Marshall Space Flight Center) Cooke, David (Air Force Research Lab.) Katz, Ira (Maxwell Technologies, Inc.) Maxwell, M. Mandell (Maxwell Technologies, Inc.) Davis, V. (Maxwell Technologies, Inc.) Hilton, J. (Maxwell Technologies, Inc.)

Published: Jan 12, 2001
Corporate Source:
Sverdrup Technology, Inc. (Huntsville, AL United States)
Pages: 1
Contract Number: NAS8-00187
NASA Subject Category: Spacecraft Design, Testing and Performance
Abstract:

The NASA Charging Analyzer Program (NASCAP) spacecraft charging software developed by Maxwell Technologies has been widely used for the past fifteen to twenty years in satellite design and investigation of spacecraft charging related anomalies. Individual versions of the NASCAP software are available for use in low inclination, low Earth orbit environments (NASCAP[LEO) and geostationary orbit environments (NASCAP/GEO). In addition, the Potentials of Large objects in the Auroral Region (POLAR) code is available for use in LEO polar orbit environments. NASCAP/GEO and POLAR were both written in the 1980's using algorithms appropriate for the computers of the time. They solve the Poisson-Vlasov system for currents and densities assuming limited speed and memory of computer systems standard for the day. In addition, use of the charging models requires individual input files that are not readily transported into the various codes to facilitate comparison of results by the user.

Major Subject Terms:
NASA PROGRAMS • SPACECRAFT CHARGING • SOFTWARE DEVELOPMENT TOOLS • SATELLITE DESIGN • COMPUTERIZED SIMULATION
Minor Subject Terms:
LOW EARTH ORBITS • POLAR ORBITS • GEOSYNCHRONOUS ORBITS • EARTH ORBITAL ENVIRONMENTS • AURORAL ZONES
Language Note: English
Notes:
7th Spacecraft Charging Technology Conference Noordwijk 23-27 Apr. 2001

TITLE: ***Arc Inception Mechanism on a Solar Array Immersed in a Low-Density Plasma***

Document ID: **20010072444** **File Series**: NASA Technical Reports
Report Number: NASA/TM-2001-211070 E-12906 NAS 1.15:211070
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Vayner, B. (Ohio Aerospace Inst.) Galofaro, J. (NASA Glenn Research Center) Ferguson, D. (NASA Glenn Research Center)
Published: Jul 01, 2001
Corporate Source:
NASA Glenn Research Center (Cleveland, OH United States)
Pages: 12
Contract Number: None
NASA Subject Category: Physics (General)
Abstract:
In this report, results are presented of an experimental and theoretical study of arc phenomena and snapover for two samples of solar arrays immersed in argon plasma. The effects of arcing and snapover are investigated. I-V curves are measured, and arc and snapover inception voltages and arc rates are determined within the wide range of plasma parameters. A considerable increase in arc rate due to absorption of molecules from atmospheric air has been confirmed. It is shown that increasing gas pressure causes increasing ion current collection and, consequently, arc rate even though the effect of conditioning also takes place. Arc sites have been determined by employing a video-camera. It is confirmed that keeping sample under high vacuum for a long time results in shifting arc threshold voltage well below -300 V. The results obtained seem to be important for the understanding of arc inception mechanism.
Major Subject Terms:
ELECTROSTATIC CHARGE SOLAR ARRAYS ARC DISCHARGES ELECTROSTATICS ARGON PLASMA
Minor Subject Terms:
ELECTRIC DISCHARGES PLASMAS (PHYSICS) ELECTRIC POTENTIAL GAS PRESSURE MOLECULES THRESHOLD VOLTAGE
Language Note: English
Notes:
Seventh Spacecraft Charging Technology Conference Noordwijk 23-27 Apr. 2001

TITLE: ***High Voltage Design Guidelines: A Timely Update***

Document ID: 20020024007 **File Series**: NASA Technical Reports
Report Number: None
Sales Agency & Price: CASI Hardcopy A01 CASI Microfiche A01 - No Copyright
Authors:
Hillard, G. Barry (NASA Glenn Research Center) Kirkici, H. (Auburn Univ.)
Published: Jan 01, 2001
Corporate Source:
NASA Glenn Research Center (Cleveland, OH United States)
Pages: 3
Contract Number: None
NASA Subject Category: Electronics and Electrical Engineering
Abstract:
The evolving state of high voltage systems and their increasing use in the space program have called for a revision of the High Voltage Design Guidelines, Marshall Space Flight Center technical document MSFC-STD-531, originally issued September 1978 (previously 50 M05189b, October 1972). These guidelines deal in depth with issues relating to the specification of materials, particularly electrical insulation, as well as design practices and test methods. Emphasis is on corona and Paschen breakdown as well as **plasma** effects for Low Earth Orbiting systems. We will briefly review the history of these guidelines as well as their immediate predecessors and discuss their range of applicability. In addition, this document has served as the basis for several derived works that became focused, program-specific HV guidelines. We will briefly review two examples, guidelines prepared for the X-33 program and for the Space Shuttle Electric Auxiliary Power Unit (EAPU) upgrade.
Major Subject Terms:
HIGH VOLTAGES SPACE SHUTTLES AUXILIARY POWER SOURCES DESIGN ANALYSIS SPACE PROGRAMS
Minor Subject Terms:
LOW EARTH ORBITS ELECTRICAL INSULATION X-33 REUSABLE LAUNCH VEHICLE ELECTRIC FIELDS PLASMAS (PHYSICS)
Language Note: English
Notes:
2001 Conference on Electrical Insulation and Dielectric Phenomena Kitchener, Ontario 14-17 Oct. 2001

TITLE: ***Electrostatic Discharge Inception on a High-Voltage Solar Array***

Document ID: 20020038747 **File Series**: NASA Technical Reports
Report Number: NASA/TM-2002-211329 E-13138 NAS 1.15:211329 AIAA Paper 2002-0631
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Vayner, B. (Ohio Aerospace Inst.) Galofaro, J. (NASA Glenn Research Center) Ferguson, D. (NASA Glenn Research Center) Degroot, W. (Siliconlight, Inc.)
Published: Jan 01, 2002
Corporate Source:
NASA Glenn Research Center (Cleveland, OH United States)
Pages: 14
Contract Number: None
NASA Subject Category: Atomic and Molecular Physics
Abstract:
In this paper, results are presented of an experimental and theoretical study of arc inception on high-voltage solar array samples and a copper-quartz junction immersed in an argon plasma. The effects of arcing are investigated over a wide range of neutral gas pressures, ion currents, and electron number densities. It is shown that the arc rate increases with increasing ion collection current. This result can be considered as an additional argument in favor of the theoretical model of arc inception as due to secondary electron emission. The effect of surface conditioning (decrease of arc rate with time due to outgassing) is clearly demonstrated. Moreover, a considerable increase in arc rate due to absorption of molecules from atmospheric air has been confirmed. Arc sites were determined by employing a video-camera, and it is shown that the most probable sites for arc inception are triple-junctions, even though some arcs have been initiated in gaps between cells. Optical spectra of arcs were measured by employing a low-noise CCD camera. The analysis of spectra (240 to 800 nm.) reveals intense narrow atomic lines (Ag, Cu, and H(sub alpha)) and wide molecular bands that confirm a complicated mechanism of arc plasma generation. The results obtained seem to be important for understanding the arc inception mechanism. Finally, the arc threshold was increased to 500 V (from 120 V) by keeping the sample in vacuum (2 microTorr) for seven days.
Major Subject Terms:
ELECTROSTATICS HIGH VOLTAGES SOLAR ARRAYS ARGON PLASMA ARC DISCHARGES
Minor Subject Terms:
SECONDARY EMISSION SPECTRUM ANALYSIS OUTGASSING DIELECTRICS
Language Note: English
Notes:
40th Aerospace Sciences Meeting and Exhibit Reno, NV 14-17 Jan. 2002

TITLE: ***The Role of Water Vapor and Dissociative Recombination Processes in Solar Array Arc Initiation***

Document ID: 20020038846 **File Series**: NASA Technical Reports
Report Number: NASA/TM-2002-211328 E-13137 NAS 1.15:211328 AIAA Paper 2002-0938
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:

Galofar, J. (NASA Glenn Research Center) **Vayner**, B. (Ohio Aerospace Inst.) Degroot, W. (Siliconlight, Inc.) Ferguson, D. (NASA Glenn Research Center)

Published: Mar 01, 2002
Corporate Source:

NASA Glenn Research Center (Cleveland, OH United States)

Pages: 18
Contract Number: None
NASA Subject Category: Atomic and Molecular Physics
Abstract:

Experimental plasma arc investigations involving the onset of arc initiation for a negatively biased solar array immersed in low-density plasma have been performed. Previous studies into the arc initiation process have shown that the most probable arcing sites tend to occur at the triple junction involving the conductor, dielectric and plasma. More recently our own experiments have led us to believe that water vapor is the main causal factor behind the arc initiation process. Assuming the main component of the expelled plasma cloud by weight is water, the fastest process available is dissociative recombination (H2O(+) + e(-) (goes to) H* + OH*). A model that agrees with the observed dependency of arc current pulse width on the square root of capacitance is presented. A 400 MHz digital storage scope and current probe was used to detect arcs at the triple junction of a solar array. Simultaneous measurements of the arc trigger pulse, the gate pulse, the arc current and the arc voltage were then obtained. Finally, a large number of measurements of individual arc spectra were obtained in very short time intervals, ranging from 10 to 30 microseconds, using a 1/4 a spectrometer coupled with a gated intensified CCD. The spectrometer was systematically tuned to obtain optical arc spectra over the entire wavelength range of 260 to 680 nanometers. All relevant atomic lines and molecular bands were then identified.

Major Subject Terms:

DISSOCIATION SOLAR ARRAYS WATER VAPOR ATOMIC SPECTRA RECOMBINATION REACTIONS ARC DISCHARGES DIELECTRICS

Minor Subject Terms:

ELECTRIC POTENTIAL PULSE DURATION CAPACITANCE ELECTRONS PLASMA CLOUDS

Language Note: English
Notes:

40th Aerospace Sciences Meeting and Exhibit Reno, NV 14-17 Jan. 2002

TITLE: ***Digital Control Technologies for Modular DC-DC Converters***

Document ID: 20020038857 **File Series**: NASA Technical Reports
Report Number: NASA/TM-2002-211369 E-13191 NAS 1.15:211369
Sales Agency & Price: CASI Hardcopy A03 CASI Microfiche A01 - No Copyright
Authors:
Button, Robert M. (NASA Glenn Research Center) Kascak, Peter E. (Ohio Aerospace Inst.) Lebron-Velilla, Ramon (NASA Glenn Research Center)
Published: Feb 01, 2002
Corporate Source:
NASA Glenn Research Center (Cleveland, OH United States)
Pages: 16
Contract Number: None
NASA Subject Category: Spacecraft Propulsion and Power
Abstract:
Recent trends in aerospace Power Management and Distribution (PMAD) systems focus on using commercial off-the-shelf (COTS) components as standard building blocks. This move to more modular designs has been driven by a desire to reduce costs and development times, but is also due to the impressive power density and efficiency numbers achieved by today's commercial DC-DC converters. However, the PMAD designer quickly learns of the hidden "costs" of using COTS converters. The most significant cost is the required addition of external input filters to meet strict electromagnetic interference (MIAMI) requirements for space systems. In fact, the high power density numbers achieved by the commercial manufacturers are greatly due to the lack of necessary input filters included in the COTS module. The NASA Glenn Research Center is currently pursuing a digital control technology that addresses this problem with modular DC-DC converters. This paper presents the digital control technologies that have been developed to greatly reduce the input filter requirements for paralleled, modular DC-DC converters. Initial test result show that the input filter's inductor size was reduced by 75 percent, and the capacitor size was reduced by 94 percent while maintaining the same power quality specifications.
Major Subject Terms:
DIGITAL SYSTEMS VOLTAGE CONVERTERS (DC TO DC) ELECTROMAGNETIC INTERFERENCE AEROSPACE SYSTEMS PHASE CONTROL
Minor Subject Terms:
COST REDUCTION CAPACITORS COMMERCIAL OFF-THE-SHELF PRODUCTS INDUCTORS WAVEFORMS
Language Note: English
Notes:
2000 Aerospace Conference Big Sky, MT 19-25 Mar. 2000

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
01-02-2003	Technical Publication	

4. TITLE AND SUBTITLE
Low Earth Orbit Spacecraft Charging Design Guidelines

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
D. C. Ferguson and G. B. Hillard

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
NASA Glenn Research Center (GRC)
Cleveland, Ohio 44135

8. PERFORMING ORGANIZATION REPORT NUMBER
M-1066

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
NASA's Space Environments and Effects (SEE) Program
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

10. SPONSORING/MONITOR'S ACRONYM(S)

11. SPONSORING/MONITORING REPORT NUMBER
NASA/TP-2003-212287

12. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified-Limited
Subject category18
Distribution: Available only with approval of issuing office: http://see.msfc.nasa.gov

13. SUPPLEMENTARY NOTES
Prepared for NASA's Space Environments and Effects (SEE) Program by the Glenn Research Center (GRC)
Technical Monitor: Jody Minor, NASA Marshall Space Flight Center, 256-544-4041

14. ABSTRACT
This report is intended as a design guideline for high-voltage space power systems (>55 volts) that must operate in the plasma environment associated with Low Earth Orbit (LEO). Such power systems, particularly solar arrays, may interact with this environmer in a number of ways that are potentially destructive to themselves as well as to the platform or vehicle that has deployed them. The fi objective is to present an overview of current understanding of the various plasma interactions that may result when a high voltage sys is operated in the earth's ionosphere. A second objective is to reference common design practices that have exacerbated plasma interactions in the past and to recommend standard practices to eliminate or mitigate such reactions.
This report is intended as a guideline for design applications and is not a requirements specification instrument.

15. SUBJECT TERMS
charging, electron, spacecraft, ion, mitigation, volt, voltage, solar, array, potential, snapover, ion, current, plasma, arc, arcing

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(Include area code)*
					Mr. Jody Minor
Unclassified	Unclassified	Unclassified	Unlimited	366	(256) 544-4041

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18